THE DISCRIMINATION AND CATEGORIZATION OF PITCH DIRECTION BY THE YOUNG CHILD

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THE DISCRIMINATION AND CATEGORIZATION OF PITCH DIRECTION BY THE YOUNG CHILD

by

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We have carefully read the dissertation entitled The Discrimination and Categorization of Pitch Direction by the Young Child **submitted by** Deborah Jeanne Kitts White **in partial fulfillment of the requirements of the degree of** Doctor of Philosophy **and recommend its acceptance. In support of this recommendation we present the following joint statement of evaluation to be filed with the dissertation.**

In an attempt to examine cognitive structures in music and particularly a theory of categorization, Deborah White has hypothesized that young children may be perceptually bound and influenced by absolute features of the musical event.

Ms. White has tested this hypothesis by examining 3 1/2- to 5-year-old children using an imaginative means (via computer and touch screen) which permits non-verbal responses from the children. By careful preparation of the musical test materials, she has been able to isolate and identify the particular focus a child employs in making discrimination and categorization decisions.

She has demonstrated a clear understanding of the application of scientific procedures to musical problems. Her findings lend impressive support to the theory that very young children can and do form clear concepts of music and that perceptual focus upon certain absolute stimulus features influences that categorization.

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Abstract

THE DISCRIMINATION AND CATEGORIZATION OF PITCH DIRECTION BY THE YOUNG CHILD

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Research has shown that preschool children have difficulty demonstrating their understanding of the relational concept of pitch direction. It was theorized that this difficulty could be due to the child's perceptual focus. Children, aged 3-1/2 to 5, were tested individually on discrimination and categorization tasks using 3-note uni-directional pitch patterns that incorporated two absolute features: pitch set and first note. Each test involved 12 trials in a 2 + 1 oddity format. The aural stimuli were presented via an Apple Computer with Touch Screen which permitted non-verbal response and the opportunity for reinspection of the exemplars.

The results of the Discrimination Test indicated that 31 of the 72 children tested focused on pitch direction, 17 attended to one of the absolute features, while 24 were unable to be identified as having a definite perceptual focus. A strong relationship between age and perceptual focus was evident with a marked increase in ability to discriminate pitch direction occurring for the 5-year-olds.

The Categorization Test offered three possibilities for the basis of categorization in each trial: pitch direction, pitch set, and first note. Feedback was given to direct attention to pitch direction. This design proved to be too complex for this age. Only 13 of the 69 children tested were able to categorize the exemplars on a significantly consistent basis. Age was not a factor in the categorization results.

In both the Discrimination and Categorization Tests, pitch set was the more prominent of the two absolute features. In the Discrimination Test 6 children were identified as having a first note focus, while 11 were identified as having a pitch set focus. In the Categorization Test, 8 children categorized on the basis of pitch set; 5 categorized on the basis of pitch direction; none categorized on the basis of first note. The results of this study indicate that some children as young as 3-1/2 can discriminate and categorize aural exemplars on the basis of pitch direction. However, the child's perceptual focus upon certain absolute stimulus features is one of the factors influencing the perception of this relational concept.

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To God, "Great is Thy faithfulness."

CHAPTER 1

INTRODUCTION

Musical development is inextricably linked to cognitive development. The processing of music involves more than the mere perception of physical sounds and silences that are present in the aural stimulus. The perceiver must derive meaning from the stimulus by being able to focus upon the organizational features that are present. Cognitive processing is essential.

One of the fundamental cognitive abilities that children must acquire when processing musical stimuli is the ability to extract meaning from an auditory stimulus that occurs over time. In this sense music perception is event perception with melody being but one part of this highly complex array. Melody occurs over time through a succession of single pitches that are highly organized and constrained by psychological (Deutsch, 1982; Lundin, 1967; Sloboda, 1985), acoustical (Benade, 1976; Roederer, 1975), and socio-cultural (Merriam, 1964; Nettl, 1983) parameters.

There are several dimensions of melody upon which the listener can focus. There are the exact pitches being heard, the precise intervals or relative distances between any two successive pitches, and the overall contour being derived from the whole set of pitches. Gibson (1983) suggests that the perception of complex events may begin with the perception of shorter embedded events contained within the stimulus configuration. One of the shorter embedded events contained within melodic structure is that of pitch direction. Pitch sequences rise and fall and thereby create the overall melodic contour. An examination of the perceptual processes involved in simple uni-directional aural pattern perception may provide important information about the perception of the more complex melodic event.

The perceptual processing of even this very simple melodic element of pitch direction requires extensive abstraction. The ability to attend to the feature of pitch direction implies a serial pattern processing ability that recognizes a relationship between the tones of the melody -- some melodic patterns rise, some fall. It is this relational feature, not the specific feature of exact pitches, that provides the critical attribute of the concept of pitch direction. A relational rather than an absolute focus is necessary.

<u>Problem</u>

Can young children attend to this relational attribute that is present in a pattern of pitches? Informal observations suggest that this is a possibility since most young children have a repertoire of familiar songs and recognize them in many different contexts. The results of a number of empirical investigations also indicates that this is a reasonable assumption. Not only is there evidence that 6-month-old infants can discriminate pitch patterns on the basis of multi-directional contour (Chang & Trehub, 1977; Trehub, Bull, & Thorpe, 1984), there is also evidence that 6- to 11-month old infants can categorize these melodies occurring in different keys and with different absolute intervals on the basis of similar contour (Summers, 1984; Trehub, Thorpe, & Morrongiello, 1987).

Narrowing the relational focus to uni-directional pitch patterns, an investigation by Thorpe (1986) has demonstrated that 7- to 10-month-old infants can also categorize auditory sequences on the basis of pitch direction. Using a visually reinforced head-turn response, the infants in that study consistently categorized two-note pitch patterns on the basis of rising and falling direction, ignoring changes in frequency and interval.

These infant studies have revealed the remarkable auditory processing capabilities of children less than one year old. However, when we turn to the evidence of the preschool child's processing of sequential auditory patterns, we are faced with a literature that is confusing at best. The assumption that preschool children can respond quite easily to the relational attribute inherent in sequential pitch patterns (since infants have been shown to do so) is not strongly supported in the research literature.

There is evidence that young children respond to the relational aspect of a set of pitches when a multi-directional contour pattern of six or more notes is used. For example, the research on young children's singing has shown that children of 4 and 5 years of age preserve contour but not exact intervals in their renditions of familiar songs (Davidson, McKernon, & Gardner, 1981), suggesting memory for global rather than specific melodic features. The studies by Morrongiello, Trehub, Thorpe, & Capodilupa (1985) and Morrongiello & Roes (1987) also demonstrate that preschool children tend to focus more on contour or relational information than on specific pitches when asked to discriminate contour-violating and contour-preserving six-note melodies.

However, the evidence for preschool children's discrimination of uni-directional, three- and four-note pitch patterns is not so clear-cut. For example, two studies that have investigated preschool children's discrimination of up and down pitch patterns have reported that 34% (Webster & Schlentrich, 1982) and 38% (White, 1983) of the 4- and 5-year-olds tested could not show evidence of this discrimination at all.

If our perceptual tendency from infancy is to process relational pitch information over specific pitch information and if uni-directional pitch patterns offer the simplest of relational pitch patterns, how is it possible that so many preschool children are reported to have difficulty discriminating this most basic melodic concept, a concept that was readily discriminated and categorized by 7- to 10-month-old infants in Thorpe's (1986) study? Serafine (1986) summed up the situation with this statement: "It is fair to say that research on infants has produced the general finding that their discrimination capacities are impressive, while research on children between two and eight years finds them surprisingly incapable of musical understanding" (p. 314). Trehub (in press) has also commented on the obvious discrepancy in the literature with this statement:

> What is puzzling, however, when considering infants' success in this endeavor is the repeated failure of other investigators to demonstrate pitch direction discrimination with preschool and young school-aged

children. It is unlikely that this ability deteriorates between infancy and later childhood. What is more likely is that young children can discriminate rising from falling pitch but that the tasks used to date simply failed to engage their interest.

Review of the Literature

Discrimination and categorization are two of the basic cognitive processes that researchers can investigate to determine an individual's level of understanding of a given concept. The infant studies previously cited have indicated that both the discrimination and categorization of pitch direction is possible at a very early age. This literature review will focus on those studies that have investigated young children's understanding of the concept of pitch direction by using either the discrimination or categorization paradigm.

For years the music research literature has been replete with references to the seeming lack of ability of young children to show evidence of their understanding of pitch concepts (Andrews & Deihl, 1970; Hattwick, 1935; Petzold, 1969; Pflederer & Sechrest, 1968; H. Williams, 1933; Wohlwill, 1971). This reported deficit has often been the result of the chosen methods of assessment.

Young children were frequently asked to sing pitches or give a verbal description of their musical understanding. While these response methods reveal a certain level of production skill or music vocabulary development, they do not speak to the issues of perceptual processing capabilities or conceptual understanding. Lack of ability to sing or verbally describe an auditory event does not necessarily indicate a lack of understanding of that event.

Of the four psychological characteristics inherent in the musical stimulus -- pitch, loudness, duration, and timbre (Lundin, 1967), pitch has emerged as the most difficult stimulus feature for young children to grasp, or perhaps more accurately stated, pitch concepts have emerged as the most difficult for researchers to investigate when using the young child as a subject. The difficulties that have arisen with the study of pitch concepts have been primarily due to the verbal references and the visual-spatial associations that have been a part of the investigations. While a change of perceived pitch is most often attributed to an increase or decrease in the frequency of the sound wave, our convention for referring to this aural phenomenon is by analogy to a spatial dimension of high-low or up-down. It is precisely these references that have caused confusion in many of the testing situations with young children. A closer look at some of the pitch direction discrimination studies will clarify this conclusion.

Discrimination Studies. Discrimination is the process of distinguishing between two or more objects and/or events on the basis of their features. One of these distinguishable features in a music stimulus is that of rising and falling pitch direction. Most young children were unable to demonstrate their discrimination of the pitch direction feature in studies that used a verbal "up-down" response as the dependent measure (Bletstein, 1984; Hair, 1977; Hattwick, 1935; Van Zee, 1976; Webster & Schlentrich, 1982). As a result of the children's poor performance on the requisite tasks, it was concluded that the traditional pitch direction terminology of "up-down" holds very little inherent meaning for the young child, especially for those below the age of 6.

However, the lack of verbal reference does not mean a lack of knowledge about an aural concept. Several pitch direction discrimination studies have used non-verbal response modes such as playing a keyboard or resonator bells (Hair, 1977; Montgomery, 1984; Van Zee, 1976; Webster & Schlentrich, 1982), gesturing up or down with an arm (Webster & Schlentrich, 1982), drawing a directional line on a piece of paper, and moving a toy up or down some stairsteps (Montgomery, 1984). The results of these studies indicate that some preschool and kindergarten children who cannot verbally describe directional pitch patterns with the conventional up-down labels, can discriminate these aural directional examples when given non-verbal tasks to perform. But, even in these "non-verbal" studies, large percentages of the children were still unable to show evidence of accurate pitch direction discrimination. It is important to note, however, that these non-verbal approaches still require the child to associate the aural phenomenon with some visual-spatial reference in order to respond. The question remains, would preschool children be able to give evidence of their aural discrimination of the relational concept of pitch direction given a task that avoided both verbal and visual-spatial reference? This possibility motivated the development of the instrumentation and procedures for this study. These will be described in the next chapter.

Some innovative response techniques have been used successfully in investigations of preschool children's discrimination of six-note multi-directional melodic contour patterns. All of the earlier-cited problems associated with verbal or spatial-association responses were avoided by using a visually reinforced hand clap (Morrongiello et al., 1985) or head-turn (Morrongiello &

Roes, 1987) response. The 2- to 6-year-old children were trained to clap their hands or turn their head when they heard a melody different from the continuously repeating standard melody. The test melodies either preserved or violated the contour of the standard melody. A correct response was reinforced with a 4-second activation of a mechanical toy.[1] The preschool children in these melodic contour studies could discriminate all transformations from the standard melody but performed with greater accuracy on those melodies that violated, rather than preserved, the contour of the standard. This indicates a perceptual priority for the relational feature of melodic contour over the absolute feature of specific pitches since a change in specific pitches only was not as obvious to the children as a change in both pitches and contour.

While not involving the discrimination of uni-directional pitch patterns, these studies do show that 2- to 6-year olds can discriminate auditory sequential pitch patterns on the basis of the relational feature of contour when given an appropriate means of response. It seems reasonable to conclude that if preschool children can deal with melodic contour patterns which involve a combination of rising and falling pitches, they could also discriminate rising from falling uni-directional pitch patterns if given an appropriate task. However, it must be noted that this conclusion is based on the assumption that since uni-directional patterns are nested within melodic contour patterns, the uni-directional patterns would be no more difficult to discriminate than the multi-directional ones. Of course this may not be true. Whatever the case, the perception of multi-directional and uni-directional melodic patterns, specified in the literature as contour and direction, must be addressed separately.

Categorization Studies. The process of discriminating various aspects of the music stimulus has remained the primary focus of much music cognitive development research. While discrimination is certainly an important cognitive ability to investigate, it is nevertheless only a first step toward the formation of concepts. At some point early cognitive activity must move beyond discriminating and begin organizing these perceptual differences into meaningful categories. We infer from this ability to categorize discriminably different objects or events that some concept has been formed; some commonality is being recognized across exemplars as the basis for the category represented. These categorizations, indicative of some sort of mental representation, help reduce the near-infinite variety of the environmental array into behaviorally and cognitively useable proportions. In reality, how could young children manage to master their general environment, and more specifically their musical environment, as effectively and efficiently as they do if they were incapable of forming categories? Rather than asking if young children can categorize, it would appear that the more important question is "what means can be employed to determine the nature and degree of categorization ability of children?"

For decades the dominance of Piaget's developmental theory which places the preschool child in a preoperational stage led many to conclude that young children were incapable of detecting abstract and invariant relations among objects and events due to their being so perceptually bound and ego-centered. Inhelder and Piaget (1964) described 2- to 5-year-old children as being in a graphic collection phase with regard to their ability to freely classify tangible objects. The preoperational children that they observed became distracted by the spatial config-uration formed by the objects being sorted and thus chose to make a "train" or build a "house" rather than sort objects on the basis of some categorical similarity. If preoperational children were truly this perceptually bound then their ability to categorize discriminably different objects and events would be severely limited, if not impossible. However the research evidence of recent years (Donaldson, 1978; Gelman, 1979; Markman, 1979) has forced cognitive developmental psychologists to re-evaluate their view of the young child's cognitive capabilities as they have discovered that the young child is far more cognitively competent than was once believed. The focus of research in child development is no longer to reveal what children do not know or cannot do, but rather to discover the children's view of the world -- what they do know and what they can do.

With this approach cognitive developmental psychologists have discovered that even very young children can easily categorize objects from their environment on the basis of some perceived similarity. These results reveal a higher level of abstraction than is predicted from Piaget's view of the sensorimotor or preoperational child, for in order to categorize discriminably different stimuli the child must be able to determine some commonality among the exemplars or perceive some relationship that exists among them. Using physiological measures such as heart rate or fixation times, a number of researchers have shown that infants, varying in ages from 4- to 10-months, do respond categorically to discriminably different visual objects such as schematic faces and stuffed animals, and also to visual dimensions such as hue and orientation (Quinn & Eimas, 1986). Studies such as those by Ricciuti (1965), Ross (1980), and Sugarman (1982) have shown that the

1-to 3-year-old child is capable of categorizing discriminably different objects such as dolls and rings by successively manipulating and spatially arranging them into distinct classes.

The categorization paradigm is also being used extensively by psychologists studying many aspects of cognitive development during the preschool years (Denney, 1972; Fischer & Roberts, 1980; Markman, 1981; Rosch, Mervis, Gay, Boyes-Braem, & Johnson 1976; Tversky, 1985). In addition to the findings from these studies which provide evidence of visual object categorization, there is also evidence that infants and young children categorize auditory stimuli as well. For instance, the categorization of speech syllables by 6-month-old infants despite variations in voice quality or pitch contour has been documented in numerous studies by Kuhl (1979, 1983, 1985). A study by Clarkson and Clifton (1985) has shown that infants can also categorize auditory stimuli on the basis of fundamental frequency, harmonic structure, intensity, and duration. These investigations provide evidence of the auditory categorization of single sounds, but the processing of music necessitates the categorizing of sequences of sounds. The discrimination and categorization of melodic patterns requires the perception of the relationship that exists between the individual pitches of those patterns.

Other than in the infant studies that have already been discussed (Summers, 1984; Thorpe, 1986; Trehub et al., 1987), the categorization paradigm has been used very little by researchers studying the development of music concepts. With preschool-aged children there are only two studies involving the categorization of music stimuli. The first is a study by Loucks (1974) examining 4- and 5-year-old children's ability to categorize auditory stimuli on the basis of instrumental timbre. The children were asked to categorize 13 musical excerpts into four timbral categories by pointing to pictures of instruments representing those categories as the aural exemplars were heard.

The second preschool categorization study is Scott's (1977) investigation of pitch concept development. Using a 3 + 1 oddity sorting task, Scott examined the 3- and 4-year-old child's understanding of the concepts of pitch register, contour, and interval. The non-verbal sorting task was accomplished by the child manipulating a set of four identical boxes. Each box contained a push button switch that activated the aural stimulus when the child lifted the box. Both of these studies indicate that with non-verbal response modes it is possible for some preschool children to categorize discriminably different auditory stimuli according to a selected criterion.

With only Loucks (1974) and Scott (1977) utilizing the categorization paradigm for music research with young children, categorization remains a viable, but mostly unused approach to the study of young children's musical cognitive development. Young children's ability or inability to categorize discriminably different music stimuli could provide further insight into their perceptual processing and conceptual understanding of the many features present in the highly complex music stimulus.

Theory

While a review of the literature reveals that infants can discriminate and categorize aural stimuli patterns on the relational basis of pitch direction, the literature also indicates that many preschool children have difficulty demonstrating an understanding of this relational concept. The verbal or visual-spatial mode of response that has been used with preschool children has been mentioned as a possible explanation for this discrepancy. Perhaps by using a response mode that requires neither verbal nor visual-spatial reference, preschool children would be able to demonstrate that they too can discriminate and even categorize pitch exemplars on the basis of this relational feature.

It is also possible that, apart from methodological considerations, the observed difficulties that young children have with the discrimination of pitch direction could be attributed to their perceptual focus. Could it be that this observed inability to discriminate pitch direction is the result of focusing on specific individual pitches for comparison of the exemplars rather than basing their discrimination on the relationship that is present between the pitches? Research by Sergeant and Roche (1973) supports this possibility. Children ages 3 to 6 years were asked to sing songs that they had been taught in training sessions. The younger children tended to sing the songs at the learned pitch level (feature-bound focus) while the older children were more accurate with the specific intervals and contour of the melody even though they sang the song in a different key from that which was learned (global, structural focus), indicating a possible change in perceptual focus. This change in perceptual focus was seen as a linear trend across the age span investigated.

Young children's perceptual focus was mentioned as a possible explanation of the results Scott (1977) obtained in the previously-cited pitch concept study with 3- and 4-year-olds. Scott found that 37% of the young children were able to demonstrate the concept of pitch register with single pitches, but the concepts of 3-pitch melodic contour and 2-pitch melodic interval, both of which involved the perception of a common relationship between a set of pitches, were much more difficult for the children to demonstrate. The concept of melodic contour was demonstrated by only 17% of the children; the concept of melodic interval by only 16% of those tested on that concept. A distinct influence of age was evident with the 4-year-olds performing better than the 3-year-olds on all concepts. As a matter of fact, only one 3-year-old was able to show evidence of the melodic contour concept, and no 3-year-olds were able to demonstrate the melodic interval concept. It should be noted however that due to the hierarchical construction of the testing procedures very few 3-year-olds were tested on these relational concepts. Nevertheless the ability to attend to the relational aspects of the contour and interval stimuli were shown to be related to the age of the child.

Piagetian theory would explain this phenomenon by saying that preoperational children, those between the ages of 2 and 6, are centered in their view of the world. Their reasoning processes are perceptually rather than cognitively controlled, thus they are easily distracted by the perceptual properties of an object or event, and because of this, often fail to detect the more abstract, invariant relations that are present in the stimulus. According to Piaget and Inhelder (1969), preoperational children are in fact not ready to deal with abstract, invariant relations at all due to their level of cognitive development. At this stage of development children have not formed the cognitive structures which would make this kind of abstraction possible.

As was mentioned earlier in the discussion of the literature on categorization, the trend in cognitive developmental research is to question the validity of this preoperational characterization of the young child. With a variety of innovative testing techniques, a number of researchers (Anderson & Cuneo, 1978; Borke, 1975; Donaldson, 1978; Gelman & Meck, 1983; Markman, 1979) have demonstrated that the young child is not as perceptually bound in the visual realm as Piaget proposed. However, the theory of perceptual boundedness has not been well-investigated as it applies to aural perception, and it may still provide a viable explanation for some young children's difficulty with aural concepts.

While we know from the infant studies (Thorpe, 1986; Trehub, et al., 1984, 1987) that relational processing of the aural stimulus is possible at a very young age, perhaps preoperational children are, as Piaget described, centered in their perceptual focus so that they do not attend to the relational features that are present in the stimulus and focus instead on specific features that are there. The evidence from studies such as Sergeant and Roche (1973) and Scott (1977) cited earlier would indicate that this is a possibility. However, rather than predicting that all preoperational children are perceptually bound, their results suggest that there is possibly a monotonic trend from a specific stimulus feature focus to a more relational focus that occurs during the preschool years with a 3-year-old responding to specific features and a 5-year-old responding more to the relational features of an aural stimulus.

Thus it was theorized that young children may experience difficulty with the discrimination and categorization of pitch direction due to their tendency to be perceptually bound. This perceptual focus would draw their attention to specific components of the aural stimulus rather than to the relational ones. It was predicted that this tendency would be age-related within the preschool years, with younger children responding to examples of pitch direction on a more absolute basis and older children responding more relationally.

According to the theory, young children may have difficulty responding to the relational concept of pitch direction because their attention is drawn to more specific features of the stimulus. Two of these specific feature possibilities are the first notes of the pitch patterns or the overall set of pitches used (see Figure 1.1).

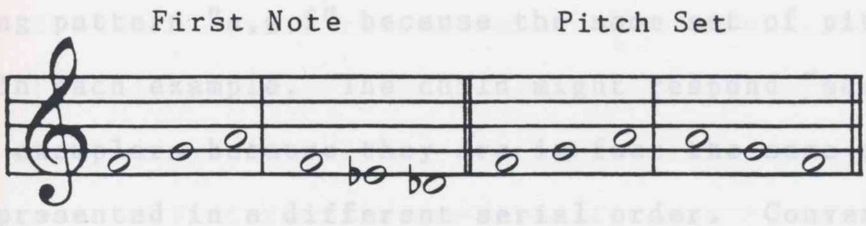

Figure 1.1. Specific features in pitch direction patterns.

For instance, a child attending to the first notes of successive exemplars would have no difficulty indicating that the rising pattern "f,g,a" is different from the falling pattern "a,g,f" but the discrimination might not be based on a consideration of the pitch direction attribute at all. The response would simply be based on the recognition that first pitch "f" is not the same as first pitch "a". A child operating on this first note strategy for comparison would have greater difficulty discriminating between the rising pattern "f,g,a" and the falling pattern "f,e-flat,d-flat" and would thus reveal the fallacy of interpreting the child's response to the "f,g,a" "a,g,f" patterns as a "correct" relational discrimination response.

Consider as another possibility the child whose focus was on specific pitches rather than the relationship between those pitches. This child might have difficulty discriminating between the rising pattern "f,g,a" and the falling pattern "a,g,f" because the same set of pitches is used in each example. The child might respond "same" to those exemplars because they are in fact the same pitches just presented in a different serial order. Conversely, for this child the same first note patterns of "f,g,a" and "f,e-flat,d-flat" might be easily discriminable, not on the basis of direction, but simply because different sets of pitches were used.

Both of these perceptual strategies, first-note and pitch set, could have confounded the pitch direction discrimination results reported by Webster and Schlentrich (1982) and White (1983). It is possible that the children who were classified as pitch direction discriminators were in fact operating on a specific feature basis rather than a relational one. In both studies the directional stimuli involved the same set of pitches for the rising and falling exemplars. Attention to the first note of the pattern could have resulted in the child's correct discrimination response, while attention to the set of pitches could have resulted in the child's seeming lack of pitch direction discrimination. Definitive conclusions about preschool children's discrimination of the relational concept of pitch direction are not possible given the limitations of the stimuli construction in these studies.

Young children's ability to discriminate and categorize pitch direction exemplars may be directly impacted by their tendency to process serial pitch patterns on the basis of some absolute feature of the stimuli rather than on the more abstract, relational basis that is necessary for an understanding of the pitch direction concept. In order to have any confidence in the discrimination and categorization data, the specific features of the stimuli must be identified and carefully controlled so that a proper interpretation of the evidence can be made.

If children are perceptually bound and not focusing upon the directional relationship that is present in the stimulus, which of these absolute features, first note or pitch set, is gaining the children's attention? Is one of these a more perceptually salient feature than another? While no study of the perceptual salience of these absolute features has been done, the results by Sergeant and Roche (1973) that were cited earlier tends to support a first note theory, for even though the 3- and 4-year-olds tended to accurately pitch the first note of the song, the intervals or succeeding notes of the melody were not precisely reproduced. This indicates that the children were attending more to the opening pitch of the song rather than to the complete set of pitches used. Considering that the first pitch is the beginning of the aural event, it automatically demands a certain amount of attention from the listener. Perceptually bound children may be so attentive to the first pitch of an exemplar that much of the remaining information in that aural event is not processed. Thus the relational concept of pitch direction would go unnoticed. It is therefore theorized that the first note feature will take perceptual priority over the pitch set feature found in the aural stimuli. Thus more pitch direction discrimination errors will occur on the first note trials due to the child's focus upon this specific feature.

It is assumed that the categorization task, which requires attention to relational similarity among otherwise dissimilar exemplars, will be more difficult for young children to perform than the discrimination task which requires a recognition of identity and difference between exemplars. Given the opportunity to categorize pitch exemplars on the basis of pitch direction, first note, or pitch set, which one will the young child choose most often? In this more demanding task, will the children who showed evidence of pitch direction discrimination continue to respond to the exemplars on the basis of their relational similarity or will the children's attention be drawn more to the first note or pitch set specific feature similarities that are present? It is predicted that the same age-related tendency to focus on absolute features of the stimuli will be present in the categorization task and that the tendency to focus upon the first note feature more than the pitch set feature will also occur.

Hypotheses

It has been theorized that young children may have difficulty with pitch direction discrimination and categorization tasks because they are perceptually bound and thus influenced by absolute features of the stimulus. This tendency is believed to be age-related with the younger child being more perceptually bound than the older child. It is also thought that the absolute feature most likely to demand the child's attention is the first note of each stimulus. The purpose of this study was to examine these theories by testing the following hypotheses with 3-1/2- to 5-year-old children:

1. Older children will discriminate pitch exemplars on a relational basis and younger children will discriminate pitch exemplars on an absolute basis.
2. Children will perform more accurately on the pitch set discrimination trials than on the first note discrimination trials.
3. Older children will categorize pitch exemplars on a relational basis and younger children will categorize pitch exemplars on an absolute basis.
4. Children will categorize more trials on the basis of first note features than on pitch set features.

Notes to Chapter 1

1. This is an adaptation of the response procedure developed by Wilson, Moore, and Thompson (1976) to obtain auditory thresholds for infants and used by Summers (1984), Thorpe (1986), and Trehub et al.(1984) in their infant studies.

CHAPTER 2

PROCEDURES

The purpose of this study was to examine young children's understanding of the concept of pitch direction by evaluating their discrimination and categorization capabilities. This evaluation was to be done without requiring the children to verbalize their understanding or to associate the aural stimulus with some sort of up-down, visual-spatial metaphor. An aural oddity task was chosen as a means of evaluating both of these capabilities. An oddity paradigm, rather than a two-stimuli comparison task, allows the child to decide a grouping and choose the one that "doesn't belong" without being forced to verbally apply "same" or "different" to a pair of exemplars. While an oddity paradigm could use four, five, or even more exemplars, it was decided to use the minimum number of three so as not to tire the child, incur a heavy memory load, or increase the possibility of distraction from the task.

Data were collected on three individual tasks: a Visual Oddity Test, a pitch direction Discrimination Test, and a pitch concept Categorization Test. Each test involved 12 trials. This number was thought to be sufficient to test the proposed hypotheses while keeping in mind the necessity of brevity when asking for responses from preschool children.

Minimal training procedures were incorporated into the design. A familiarization phase occurred prior to the aural discrimination and categorization testing to allow the children to become acquainted with the instrumentation. Demonstration trials were also included prior to the three individual assessments to make sure that the child understood the procedures. Feedback was provided after each response to help maintain the child's interest in the task and also to direct the child's attention to the correct stimulus focus if an incorrect response was given. Without this directed attention, the child might not have understood that there was a "correct" response to the task. A study by Gelman (1969) showed the importance of feedback to young children's successful performance on an oddity task. Kindergartners in her study who were simply exposed to the stimuli and given no feedback showed no grasp of the concept under consideration after 32 trials, but those who received informative feedback responded correctly within 10 trials. Thus feedback was provided in this study so that the children who were capable of focusing on the relational concept of pitch direction would be encouraged to do so.

Instrumentation

The development of instrumentation to carry out an aural oddity task without any reference to verbal or visual up-down associations from the investigator or the children was of primary importance. The newly developed computer hardware known as the Touch Screen, (Apple IIe Touch Window #1000, Personal Touch Corporation, 1985) was utilized to accomplish this purpose. The Touch Screen is a transparent, pressure-sensitive surface that is placed over the computer's monitor screen. It simplifies a child's interaction with the computer so that by simply touching the screen the child can either give or receive information. The computer program for this study was designed such that by touching the visual designs that appeared on the screen for each trial, the child could listen to each of the three aural stimuli and then indicate the one that was "different" simply by re-touching the visual design that had activated that particular aural pattern.[1] Figure 2.1 provides a sample screen layout.

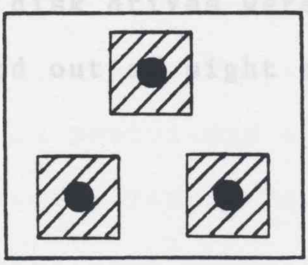

Figure 2.1. Example of Touch Screen layout.

The investigator controlled the advancement to each trial by using a hand-held numeric keypad (Model #A2M2003) that was attached to the computer. This allowed the children the freedom to touch the visual designs on the screen and listen to the aural stimuli as many times as necessary before giving their "different" response. When the child responded correctly, the investigator used the keypad to advance to the next trial with the computer automatically recording the child's response. If the child's response was incorrect, the investigator used the keypad to send a message to the computer to record the child's incorrect response before corrective feedback was provided. The investigator advanced to the next trial after the feedback was given.

The Touch Screen was attached to a color monitor (Amdek Color-I) which was placed on a two-shelf adjustable computer table (Highsmith #L9-77810). The Touch Screen monitor was placed on the lower shelf at a comfortable height for the child to use while seated, the computer keyboard and two disk drives were placed on the upper shelf, covered and out of sight so as not to distract the child.

Pilot Study

In order to test the suitability of the Touch Screen to this type of research task, to determine appropriate age parameters, and to evaluate the graphic design choices for the visual stimili, a pilot study was conducted in May and June 1987 at the Child Development and Mental Retardation Center on the University of Washington campus. Seven children ranging in age from 30-months to 7 years participated in the study involving both discrimination and categorization trials. All of the children enjoyed interacting with the computer, touching the visual designs on the screen, and listening to the resulting aural patterns. Consequently, the Touch Screen with keypad attachment proved to be a viable way to present aural stimuli and record responses in the non-verbal and non-visual-associative manner desired.

Based on the evidence acquired from these children in the pilot study, it was decided that 30-month-old children were too young to comprehend the oddity task. The two 30-month-old children who participated in the pilot study were already subjects in a University of Washington research project on precocious children. Thus in many ways they were considered advanced for their age. While they enjoyed "playing the game", their random responses to the oddity task were uninterpretable. It was also decided that children over 5-1/2 years of age would not make the most interesting subjects for this study, since they performed the tasks quite easily and the data would simply represent a ceiling effect. The ages of 3-1/2, 4, and early 5 (42 to 65 months) emerged as the most appropriate for an investigation of this type. Other studies have shown that remarkable growth in the understanding of musical concepts occurs during these ages (Montgomery, 1984; Scott, 1977; White, 1983) and it was also children of these ages that seemed to respond to the absolute features of pitch in the Sergeant and Roche (1973) study cited in Chapter 1.

The pilot study revealed some distinct changes that needed to be made in the visual stimuli. These will be discussed as the visual stimuli are described later in this chapter.

Participants

The children who participated in the main study were 3-, 4-, and 5-year-olds who were enrolled in six preschool classes at the Woodinville Christian School. One week prior to the first session, the parents of these children were sent a letter explaining the purpose and nature of the study and asking for permission for their child to participate. About two weeks later, a second letter was sent to the parents updating them on the progress of the research project and reminding them of the importance of their child's attendance on the data collection days. A consent form and an information sheet was also sent (see Appendix A). Before the child was accepted as a participant, the consent form had to be signed and returned to the experimenter and the information sheet had to verify that the child had normal hearing ability. Parents were also asked to provide information concerning any prior musical training. While all of the children had participated in the music time at preschool, only two were reported to have had any formal music training. This training involved less than 3 months of piano lessons for these two children.

A total of 87 children were enrolled in these six preschool classes. Because of absences (1) and lack of consent (6), 80 children participated in the first phase of the study, the Visual Oddity Test. Prior to the Discrimination phase seven children were eliminated from the study, five because they exceeded the upper age limit of 65 months, one child moved, and one did not reach criterion on the Visual Oddity Test. In addition to these, one child was uncooperative during the discrimination testing and was thus eliminated from the study as well. Thus, data were obtained for 72 children in the Discrimination phase.

Due to three children's absences, only 69 of these children participated in the Categorization phase.

In order to test the age-related hypotheses, the children were grouped into four six-month age categories (3-1/2, 4, 4-1/2, 5) according to their age at the time of the first session. Table 2.1 presents the number of children that participated in each of the three data collection sessions tabulated according to six-month age category and sex.

Table 2.1

Participants in the Data Collection Tasks

	Tasks		
Age/Sex	Visual Oddity	Discrimination	Categorization
3-1/2			
Boys	7	6	6
Girls	9	8	8
4			
Boys	11	11	10
Girls	7	7	7
4-1/2			
Boys	12	11	9
Girls	6	6	6
5			
Boys	8	8	8
Girls	15	15	15
5-1/2			
Boys	5	0	0
Total	80	72	69

Implementation

The testing environment is of utmost importance when dealing with young children for they are easily distracted or disturbed by their surroundings. It was decided to conduct this research on-site at the children's school during the course of normal preschool days so that the children could remain in familiar surroundings. This was also a more convenient way to schedule various individual and group times with a large number of children. Due to young children's limited attention span, it was also decided that the experimental procedures should happen in several brief daily sessions rather than one or two lengthy ones.

The data collection occurred between January 12 and May 5, 1988. In order to fit into the school's structure, the experimenter worked with six intact classes of 14-15 children each. There were eight days of involvement with each preschool class. This allowed time for the children to become familiar with the investigator, the computer touch screen, and the aural and visual stimuli prior to the testing. It also allowed ample time for the individual pitch direction discrimination and categorization tasks to be completed. Two of these days involved activities with the class as a whole. For example, the first day was a get-acquainted time with the investigator being a "helper" in the classroom; on another day the computer was placed in the classroom to allow time for the children to become familiar with the computer and the aural and visual stimuli that it provided. The remaining six days were available for individual discrimination and categorization testing. So as not to interrupt the regular preschool day schedule, all testing was done during the "free-choice" time that occurred at the beginning of each class session. It was assumed that seven children could be individually tested during this free-choice time, thus two days were allowed for each of the three individual evaluations, which included a visual oddity discrimination task, a pitch direction discrimination task, and a pitch concept categorization task. The individual testing took place in a room that was close by, but separate from, the preschool class. At the end of each individual testing session the child was allowed to choose a colorful sticker reward to encourage continued cooperation and participation. These proved to be very successful.

The daily sessions for each preschool class were conducted as follows:

<u>Phase I</u> - <u>Introduction</u> (1 day)

Design: 45 minute involvement in class during free-choice time

Purpose: This allowed the investigator to meet each child and become familiar with classroom routines.

Data: None

<u>Phase II</u> - <u>Visual Oddity Test</u> (2 days)

Design: 2-minute individual test

1 demonstration trial

12 trials with feedback

The script for this phase appears in Appendix B.

Purpose: This session allowed the child to become familiar with the testing environment and the investigator in a one-on-one situation. The child also gained experience using the computer touch screen and responding to the oddity paradigm.

Data: The computer tabulated the number of correct responses for each child and the investigator recorded this information on the Subject Data Sheet (see Appendix C). The data were examined to determine if the child understood the oddity game. In order for the oddity task to be performed successfully the child had to be able to compare three stimuli on some basis and determine that two of the three were the "same" or "go together" and one was "different" or "doesn't belong". It was assumed that if a child could not accurately respond to a visual oddity task, there could be no confidence in the data obtained in the aural oddity task. Therefore the criterion for continuing in the study was set at 10 out of 12 correct on this particular task.

<u>Phase III</u> - <u>Familiarization</u> (1 day)

Design: 10 displays on the monitor

The computer was available for free exploration during the entire preschool session so that the children could "play" with the computer with minimal adult assistance. It was assumed that children's natural curiosity would bring them to the computer without coercion, and that their short attention span would prevent them from staying on task for longer than a few minutes at a time. The children were allowed to play with the computer individually or in small groups and a child could return to the computer as time allowed throughout the day.

So that the investigator did not have to be so closely involved, the program automatically advanced to the next screen display two seconds after all three exemplars had been touched. This allowed ample time for the last-touched exemplar to sound before the screen changed visually. The 10 displays occurred on a continuous loop so that display number 1 automatically returned after display number 10 without interruption. The script for this phase appears in Appendix B.

Purpose: To allow the children to become familiar with the aural and visual stimuli on the touch screen as they would occur in the discrimination and categorization phases of the study.

Data: There were no response data for this phase. The investigator observed the children and monitored the amount of time spent with the computer making sure that all of the children received some exposure. Observations were recorded on a Subject Data Sheet (see Appendix C).

<u>Phase IV</u> - <u>Discrimination Test</u> (2 days)

Design: 6-minute individual test

5 demonstration trials:

2 visual, 3 aural/visual

12 trials with feedback

See Appendix B for the script for this phase.

Purpose: To obtain data on each child's ability to discriminate pitch direction and determine if there were performance constraints due to an absolute focus on the first note or pitch set of the stimulus.

Data: The position of all responses was recorded and the number of correct responses was tabulated for each child. This score was recorded on the Subject Data Sheet (see Appendix C).

Phase V - Categorization Test (2 days)

Design: 6-minute individual test

1 demonstration trial

12 trials with feedback

The script followed the format presented for Phase IV (See Appendix B).

Purpose: To obtain data on each child's ability to categorize pitch direction exemplars and determine if there were performance constraints due to an absolute focus on the first note or pitch set of the stimulus.

Data: The position of all responses was recorded for later analysis. The number of trials categorized by pitch direction was noted on the Subject Data Sheet (see Appendix C).

Visual Stimuli

The interpretation of the response is always a problem in testing young children. Given the option to choose one item from a visual array, some children may base their choice on the item's position on the screen rather than on the aural information provided. For this reason the three exemplars in a given trial were placed in four different visual configurations each offering a left, middle, and right choice. These four patterns randomly occurred in all of the tasks (see Figure 2.2).

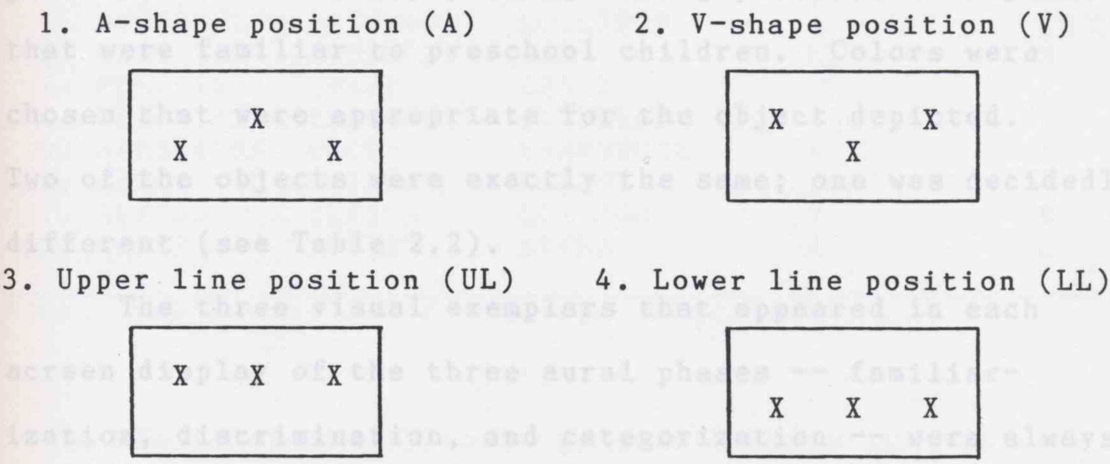

Figure 2.2. Configurations for screen displays.

The "correct" response position was also randomized within the configuration. Each response position was recorded and analyzed to determine if there was any position effect. For the convenience of the investigator, the trial number and the correct response position appeared in the upper or lower left corner of the screen, for example "9m" would indicate trial number nine with the correct answer located in the middle position of that particular screen display.

Visual stimuli were used in four phases of this study: Visual Oddity, Familiarization, Discrimination, and Categorization. All visual stimuli were designed with the aid of the Koala Micro Illustrator (1984).

Visual Oddity Test. The Visual Oddity Test incorporated a 2 + 1 oddity paradigm using pictures of objects that were familiar to preschool children. Colors were chosen that were appropriate for the object depicted. Two of the objects were exactly the same; one was decidedly different (see Table 2.2).

The three visual exemplars that appeared in each screen display of the three aural phases -- familiarization, discrimination, and categorization -- were always identical in shape and color for that particular display so that no distracting feature could influence the response. Otherwise the child's response might be attributed to an interesting visual feature rather than to the aural information provided by touching these designs. The shapes were approximately 3-inch circles and squares of varying colors with small circles or squares of a contrasting color (varying in size from 1/2 inch to 1 inch) in the center to draw the child's attention to touch the middle of each design.

Table 2.2

Visual Stimuli for Visual Oddity Test

Trial	Screen Position			Screen Display	Response Position
	Left	Middle	Right		
A.	UMBRELLA	UMBRELLA	JACK-IN-BOX	A	R
1.	CHAIR	RABBIT	RABBIT	V	L
2.	ICE CREAM	DUCK	ICE CREAM	UL	M
3.	BIRD	BIRD	FOOTBALL	LL	R
4.	PIG	KITE	PIG	V	M
5.	BUTTERFLY	BUTTERFLY	LOLLIPOP	A	R
6.	CAR	SANDWICH	CAR	LL	M
7.	PUMPKIN	CHAIR	CHAIR	UL	L
8.	ELEPHANT	ELEPHANT	AIRPLANE	LL	R
9.	HAMBURGER	WAGON	HAMBURGER	A	M
10.	FROG	CARROT	CARROT	UL	L
11.	SLEIGH	SLEIGH	HOT DOG	V	R
12.	SHEEP	APPLE	APPLE	A	L

Note. See Figure 2.2 for screen displays.

In the pilot study, those graphic designs that had a contrasting color in their center proved to be the best at drawing the child's attention to touch the center of the design. Without the emphasis on the center, some children preferred to touch only the edge, which was not as touch sensitive and, depending on the exact placement of their small fingers, would not always activate the aural stimulus. Others preferred to outline the entire figure which would produce several repetitions of that aural stimulus. However with a small area of contrasting color in the center of the design, the children tended to touch that area and then listen to the subsequent aural pattern that their touch produced without being prompted by the investigator.

To encourage the child's attention to the task, the visual designs varied in color and shape from trial to trial, and the complexity of the designs increased as the sessions proceeded. Light and dark shades of blue, orange, green, and purple were used along with black, gray, and white to create a variety of interesting patterns. Sometimes the large circle or square was horizontally or vertically split into two different colors to offer more visual variety (see Figure 2.3).

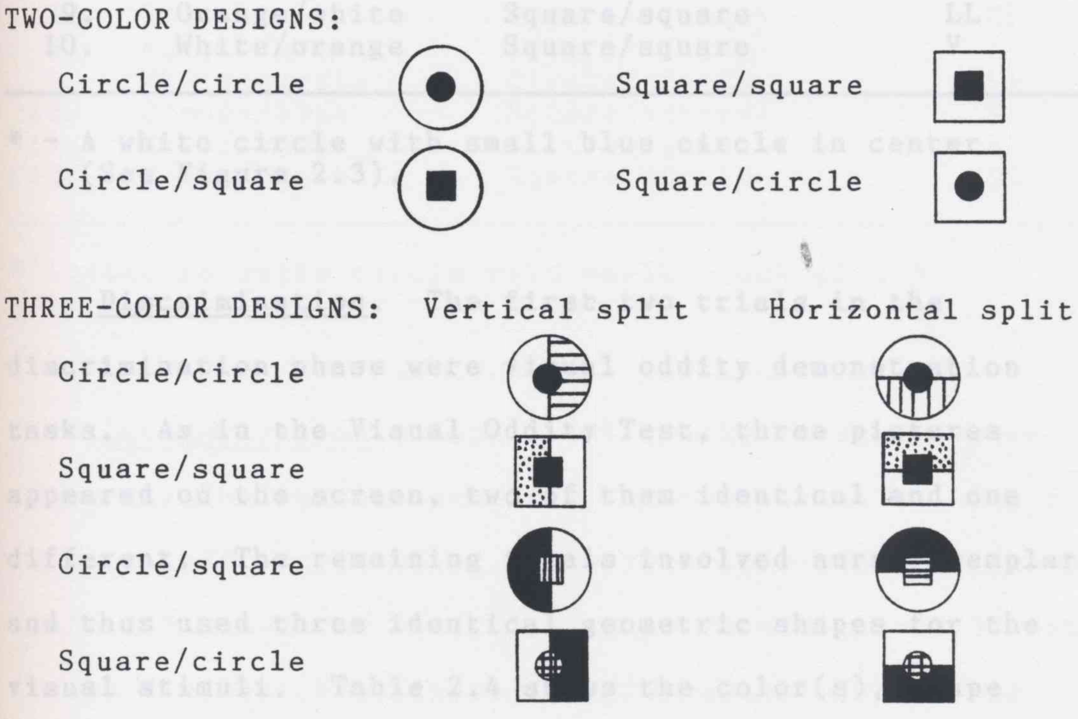

Figure 2.3. Visual stimulus designs.

Familiarization. Table 2.3 gives the color, shape (see Figure 2.3), and screen display (see Figure 2.2) that was used for each of the 10 demonstrations of the Familiarization Phase.

Table 2.3

Visual Stimuli for Familiarization Phase

Demo	Color	Shape	Screen Display
*1.	White/blue	Circle/circle	A
2.	Blue/orange	Circle/circle	V
3.	Green/white	Circle/circle	UL
4.	Gray/blue	Square/square	LL
5.	Purple/black	Square/square	V
6.	Orange/green	Square/square	LL
7.	Gray/purple	Circle/circle	UL
8.	Purple/gray	Circle/circle	A
9.	Orange/white	Square/square	LL
10.	White/orange	Square/square	V

* - A white circle with small blue circle in center (See Figure 2.3).

Discrimination. The first two trials in the discrimination phase were visual oddity demonstration tasks. As in the Visual Oddity Test, three pictures appeared on the screen, two of them identical and one different. The remaining trials involved aural exemplars and thus used three identical geometric shapes for the visual stimuli. Table 2.4 shows the color(s), shape (see Figure 2.3), and screen display (see Figure 2.2) for each trial of the Discrimination Test.

Table 2.4

Visual Stimuli for Discrimination Test

Trial	Color	Shape	Screen Display
A.	FOOTBALL/SQUIRREL/FOOTBALL		UL
B.	FROG/FROG/LOLLIPOP		V
*C.	White/black	Circle/circle	A
D.	Orange/white	Square/square	LL
E.	Green/black	Circle/circle	UL
1.	Gray/blue	Circle/circle	A
2.	Green/purple	Circle/circle	V
3.	Orange/white	Square/square	UL
4.	Blue/gray	Square/square	LL
5.	Purple/green	Circle/square	V
6.	White/orange	Circle/square	LL
7.	Blue/black	Square/circle	UL
8.	Purple/green	Square/circle	A
9.	White/purple	Circle/circle	LL
10.	Orange/blue	Square/square	V
11.	Gray/orange	Circle/square	A
12.	Green/black	Square/circle	UL

* Indicates white circle with small black circle in the center.

Categorization. Each trial in the categorization phase involved aural exemplars, so the visual stimuli for those trials consisted of three identical geometric shapes. Table 2.5 shows the color(s), shape (see Figure 2.3), and screen display (see Figure 2.2) for each trial of the Categorization Test.

Table 2.5

Visual Stimuli for Categorization Test

Trial	Color	Shape	Screen Display
A.	White/black	Square/square	V
1.	Blue/orange	Square/square	A
2.	Green/white	Circle/circle	V
3.	Purple/gray	Square/circle	UL
4.	Orange/green	Circle/square	LL
*5.	White/blue/orange	Vertical split S/s	V
6.	Green/orange/blue	Horizontal split S/s	LL
7.	Purple/gray/black	Vertical split C/c	A
8.	Blue/orange/gray	Horizontal split C/c	UL
9.	Orange/white/black	Vertical split S/c	LL
10.	Gray/green/purple	Horizontal split C/s	V
11.	Blue/orange/white	Vertical split C/s	UL
12.	White/green/purple	Horizontal split S/c	A

* Indicates a vertical split white and blue square with a small orange square in the center.

Aural Stimuli

A pitch direction pattern can involve many features: number of notes, set of pitches, extensity of the pattern, intervals between the various pitches, tonality of the patterns, the first note of the pattern, contour complexities, pitch register, and also the duration, loudness, and timbre of the separate pitches. Since this was a study of the concept of pitch direction, it was decided to keep the directional component of the patterns as simple as possible by using only uni-directional exemplars. The number of pitches in each exemplar was set at three, since both Webster and Schlentrich (1982) and White (1983) in earlier investigations of pitch direction discrimination with preschool children found no significant differences in the reponses to two-, three-, and four-note pitch direction patterns. The three-note patterns are believed to be long enough to provide adequate information about pitch direction and yet short enough so as not to lengthen the task unnecessarily. The three-note pattern has also been shown to minimize the effect of the interval between the pitches of the directional pattern (D. Williams, 1975).

Concerning the choice of the interval between the pitches, D. Williams (1975) found that while three notes were adequate to provide a sense of melodic direction they also minimized the influence of the interval size, or distance, between the pitches that was evidenced with 2-note patterns. In his study with elementary school children, the interval between the pitches of the ascending and descending exemplars had an impact on pitch direction discrimination when only two-pitch exemplars were used. However, when three-pitch exemplars were used there was almost no effect due to interval size. Webster and Schlentrich (1982) also found no statistically significant differences due to interval when comparing preschool children's responses to directional patterns using major

2nds or those using perfect 4ths and 5ths. The study by Thorpe (1986) also showed that infants could discriminate pitch direction patterns ignoring differences in interval; and they were successful on patterns involving an interval of only a semitone.

Assuming then that the choice of interval would not greatly affect the perception of pitch direction, the major second was chosen as the interval between the successive pitches of the exemplars for both the discrimination and categorization tasks. This interval represents a common one from young children's song repertoire (Dowling, 1988; Moog, 1968/1976) and thus should be familiar to them. The three-note, major-second patterns also represent familiar diatonic context to the children. A study by Trehub, Cohen, Thorpe, and Morrongiello (1986) indicated that diatonic structure already has an impact on 4-year-old children's melodic perception.

The selected pitch register was mid-range (A3 - C5) in order to remain as close to the child's singing range as possible since Zwissler (1972) found that pitches in that range are easier for the young child to discriminate. Of the remaining variables, the first note of each pattern and the set of pitches used for the pattern were examined to test the hypothesis that children's perceptual focus on these absolute features, rather than on relationships, may have an influence on their ability to discriminate and categorize pitch direction patterns.

The aural stimuli were constructed by using the Timbre Editor from Programmer's Arts Resource Tools (Williams & Bowers, 1986), generated by the computer using the Micro Music DAC Board, and played through an 8-ohm external speaker. Since the focus of this study was on pitch, the factors of duration, loudness, and timbre were held constant. D. Williams (1975) found that changes in these dimensions did have an influence upon elementary school children's pitch perceptions. The aural stimuli were constructed using a complex waveform with attack and decay transients resembling a xylophone timbre since this was the timbral preference of preschool children in Scott's (1977) study. The loudness level, subjectively determined to be comfortable for listening, was the same for all aspects of the experiment. The duration of 200 ms. for each tone and intertone interval was used throughout, making each three-note exemplar last a total of one second. This duration was chosen on the basis of the results obtained by Morrongiello & Roes (1987). In their study of six-note melodic contour perception, they manipulated the task difficulty by presenting the melodies to the young children at four different rates: 1.5, 2.5, 4.5, and 5.5 tones per second. They found that the children's responses were more stable with attention to both interval and contour at the intermediate rates.

Three phases of the study used aural stimuli: Familiarization, Discrimination, and Categorization. In each trial of these tasks the activation of the aural stimuli was dependent upon the child touching the visual designs on the screen. This affected two features of the aural stimulus presentation. First, the inter-stimulus time for each trial varied according to the touching pace of the child. Also, the presentation order of the three exemplars within each trial varied according to the child's touching order.

Familiarization. In the Familiarization phase the aural stimuli for each screen display was comprised of three identical three-pitch exemplars either all ascending or all descending. See Figure 2.4 for the pitches used for all three aural exemplars occurring in each demonstration.

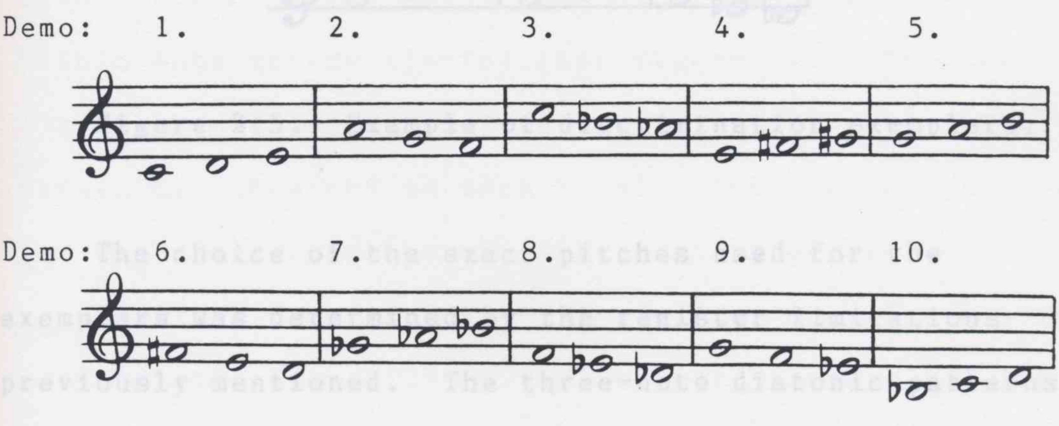

Figure 2.4. Aural stimuli for familiarization displays.

Discrimination. The aural stimuli for the discrimination task were constructed so as to examine the effects of the stimulus design features, first note and pitch set, upon the child's ability to discriminate pitch direction. In a given trial, two of the three aural exemplars were identical using the same pitches and the same direction; one was different by direction but used either the same pitches or the same first note of the identical pair (see Figure 2.5). Six of the trials were designated as pitch set trials; six were designated as first note trials.

Pitch Set Trial

First Note Trial

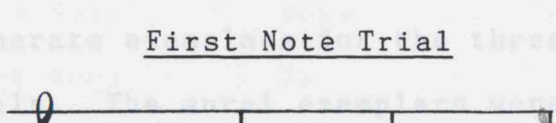

Figure 2.5. Example of discrimination exemplars.

The choice of the exact pitches used for the exemplars was determined by the register limitations previously mentioned. The three-note diatonic patterns needed to occur within the designated range of A3 to C5.

Also, because of the pitch set and first note constraints, the pitch patterns needed to be able to rise or fall from the beginning pitch, thus limiting the possible starting pitches to C#4 as the lower limit and A-flat4 as the upper limit. Since four trials could be generated from each starting pitch -- a pitch set condition with a rising exemplar as the correct response, a pitch set condition with a falling exemplar as the correct response, a first note condition with a rising exemplar as the correct response, and a first note condition with a falling exemplar as the correct response -- only three starting pitches had to be chosen to generate the aural stimuli for the 12-item task. The starting pitches of D, F, and G were arbitrarily chosen as the beginning pitches for the discrimination exemplars; the pitches of E and F# were chosen to generate exemplars for the three aural demonstration trials. The aural exemplars were designated to occur in either the left, middle, or right screen positions within each screen display (see Figure 2.2), but this placement did not reflect the aural stimuli presentation order that occurred in each trial. The presentation order was dependent upon the child's touching order.

Table 2.6 indicates the randomized stimulus design feature, the direction of the correct response and the correct response position for each trial of the discrimination phase.

Table 2.6

Randomization of Aural Stimuli for Discrimination Test

Trial	Design Feature	"Different" Direction	Correct Response Position
A.	(Visual Oddity Demo)		Middle
B.	(Visual Oddity Demo)		Right
C.	Pitch Set	Up	Left
D.	First Note	Down	Right
E.	Pitch Set	Up	Left
1.	Pitch Set	Down	Middle
2.	First Note	Up	Left
3.	First Note	Down	Right
4.	Pitch Set	Up	Left
5.	First Note	Up	Middle
6.	Pitch Set	Down	Right
7.	First Note	Down	Left
8.	Pitch Set	Up	Right
9.	First Note	Down	Middle
10.	Pitch Set	Down	Left
11.	Pitch Set	Up	Middle
12.	First Note	Up	Right

The pitch patterns and screen positions for the aural stimuli in the discrimination task are presented in Figure 2.6.

Figure 2.6. Aural stimuli for discrimination test.

Note. Trials A and B were visual oddity demonstrations.

Categorization. The aural stimuli for the categorization task were constructed so as to examine the effects of direction, first note, and pitch set upon the child's ability to categorize three-note, ascending or descending, pitch exemplars. Because each exemplar in a trial had to be unique, it was possible to construct each trial such that any two of the exemplars could be categorized on some basis. For each categorization trial two exemplars shared the same pitch direction, two shared the same first note, and two shared the same pitch set. Thus all three response strategies were possible within each trial(see Figure 2.7). For instance, in this example if the child chose the left exemplar as being the different one, this would imply a categorization basis of direction. If the middle one were chosen, the implied basis of categorization would be first note; if the exemplar on the right were chosen, the implied basis of categorization would be pitch set.

Strategy: Direction First Note Pitch Set

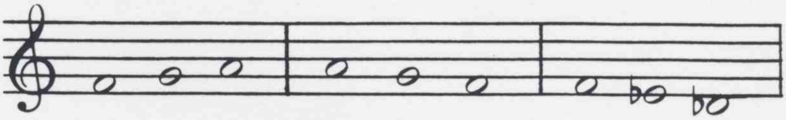

Figure 2.7. Example of categorization exemplars.

Since each trial contained both first note and pitch set constraints, six different starting pitches could be incorporated into the 12-trial design, each one being used to generate a rising and a falling pitch direction categorization response trial. The pitches C#, E-flat, E, F, F#, A-flat were arbitrarily chosen as the beginnings for the three-note diatonic patterns with G being used for the demonstration trial. Again, the left, middle, and right screen positions were designated within each trial, but the actual presentation order was dependent upon the child's touching order.

Table 2.7 shows how the screen position and directional emphasis of each set of three exemplars randomly varied so that the choice of the "different" exemplar would indicate a possible categorization strategy.

Table 2.7

Randomization of Aural Stimuli for Categorization Test

	SCREEN POSITION		
Trial	Left	Middle	Right
A.	First Note	Pitch Set	Direction-Down
1.	Direction-Up	First Note	Pitch Set
2.	Pitch Set	Direction-Down	First Note
3.	First Note	Pitch Set	Direction-Up
4.	Pitch Set	Direction-Down	First Note
5.	First Note	Pitch Set	Direction-Down
6.	Direction-Up	First Note	Pitch Set
7.	First Note	Pitch Set	Direction-Up
8.	Direction-Down	First Note	Pitch Set
9.	Pitch Set	Direction-Up	First Note
10.	Direction-Up	First Note	Pitch Set
11.	First Note	Pitch Set	Direction-Down
12.	Pitch Set	Direction-Down	First Note

The pitch patterns and screen positions for the aural stimuli used in the categorization test are presented in Figure 2.8.

Figure 2.8. Aural stimuli for categorization test.

Data Analysis

Response data from the Visual Oddity, Discrimination, and Categorization Tests were stored by computer on diskettes and analyzed in the Systematic Musicology

Laboratory using an IBM-AT computer and programs from the Statistical Package for the Social Sciences (1986). Scores on these three 12-item tasks served as dependent measures.

The primary independent variable in both the discrimination and categorization phases was age of the participant. Age was recorded in months and analyzed according to four categories (42 to 47 months, 48 to 53 months, 54 to 59 months, and 60 to 65 months).

Additional independent variables were stimulus design features. In the discrimination test, two types of trials, first note or pitch set, were identified according to their stimulus constructions. In the categorization test, each trial presented three possible response choices -- pitch direction, first note, or pitch set.

An alpha level $\leq .05$ was set for all tests of significance. If statistical significance was found on any of these measures, post hoc analyses were applied to determine the source of significance.

A Subject Data Sheet (see Appendix C) was kept for each child with the investigator writing comments about the child's performance on each task. Particular notice was given to the child's interest and attention to the task; verbal comments concerning the test were also noted.

Notes to Chapter 2

1. This computer program was developed by Don Dunn, a University of Washington student who was employed by the University's Child Development and Mental Retardation Center.

CHAPTER 3

RESULTS

This chapter reports analyses of the data for three phases of this study: the Visual Oddity Test, the pitch direction Discrimination Test, and the pitch concept Categorization Test.

Reliability

To ensure the accuracy of the computer program to record the child's response position and also to verify that the investigator accurately monitored the progress of the test by either advancing to the next trial when the child's answer was correct or recording the child's incorrect response before providing feedback, 20 testing days were videotaped. This resulted in tapes of 29 of the 80 Visual Oddity Tests, 47 of the 72 Discrimination Tests, and 51 of the 69 Categorization Tests. The Visual Oddity Test tapes were not reviewed since 95% of the children scored with 100% accuracy. The investigator did review 27 Discrimination Tests (37% of the total tests) and 21 Categorization Tests (30% of the total tests).

No discrepancies between the videotape and the record of responses were discovered.

A graduate of the University of Washington's Systematic Musicology department also viewed a random selection of about 10% of the discrimination and categorization testing sessions. This process involved a review of 192 trials. The reviewer marked the child's response on a score sheet and noted the investigator's reactions as well. There was agreement on 191 of the 192 trials, resulting in an inter-rater reliability of $\underline{r}$ = .99 ($\underline{r}$ = agreements / agreements + disagreements).

The reliability of the discrimination and categorization tests was estimated using the split-half method of analysis. Scores on the odd- and even-numbered trials were used to form the two sets of data for each test. The stimulus design features of first note and pitch set had not been counterbalanced over the odd and even trials. To achieve a balance of these features on each half test, trials 7 and 8 were interchanged in both the discrimination and categorization tests for this analysis. The variances for both test halves were calculated and the reliablility of the half test was estimated with the formula $\underline{r}$ = variance a / variance b. This yielded an $\underline{r}$ of .73 for the discrimination half-test and an $\underline{r}$ of .91 for the categorization half-test. This coefficient is a simple proportion of the variances of the test halves.

The Spearman-Brown formula (Ferguson, 1981), was used to estimate the reliability of the whole test. This formula estimates what the reliability would be if each test half were doubled. The estimate of reliability for the whole discrimination test was $\underline{r}$ = .84; the estimate of reliability for the whole categorization test was $\underline{r}$ = .95.

Visual Oddity Test

Eighty children participated in this phase of the study. The data were raw scores of the total number of items correct on the 12-trial Visual Oddity Test. The data were examined to determine if the children understood the oddity game. Prior to the testing, it was decided that a child who understood the game should be able to answer at least 10 of the items correctly. The criterion was set at a high level because it was assumed that 3-year-olds would be able to discriminate visually with a high degree of accuracy. If a child should answer less than 10 correct on this first oddity task, no further data for that child would be examined because there could be no confidence in the meaning of the responses to subsequent oddity tasks. A perfect score of 12 was obtained by 76 (95%) of the children. Three of the children scored an 11. Only one child failed to reach the criterion set as a basis for continuing in the aural discrimination phase. This child tended to respond to favorite objects rather than to the "different" one and scored a 9 on this task.

<u>Discrimination Test</u>

Seventy-two of the 80 children who participated in the Visual Oddity Test participated in this part of the study; 36 were boys and 36 were girls. The mean age was 54.8 months. The data obtained in this phase were the number of correct scores on the 12-trial pitch direction discrimination test. Each trial presented the child with three exemplars in a 2 + 1 oddity format. The child was asked to choose the exemplar that was different. Since two of the three exemplars in each trial were identical there were only two response choice types possible, an ascending one or a descending one. The "different" exemplar shared either the pitch set or the first note feature with the other two.

The question to be answered with the task was this: Could the child discriminate on the basis of pitch direction regardless of the first note or pitch set constraints provided by the stimulus construction? If the answer was "yes", the child should have done equally well on all test items. If the child was attending to the first notes of the exemplars, those exemplars that all shared the same first note (e.g., Figure 2.6, Trial 2) should have been difficult to discriminate and more errors should be evident there. If, on the other hand, the child was attending to the set of individual pitches used, those exemplars that used the same pitches (e.g., Figure 2.6, Trial 1) should have been more difficult to discriminate and more errors should be evident there. If, however, errors should occur on both types of stimuli, the child may have been attending to one and then the other of the absolute features of the stimuli, or perhaps there was no perceptual strategy at all and the responses were simply random. Whatever the case, this random type of response profile would be, for the most part, uninterpretable.

Using these four response profiles, a descriptive analysis of the data was possible. A criterion of at least 5 out of 6 correct on each of the two types of trials (p = .016) was set as the basis for this analysis. Figure 3.1 describes the procedures used to classify children on the basis of their responses.

The children who seemingly responded correctly on the basis of pitch direction to at least five out of the six pitch set items might have been discriminating the relational attribute of pitch direction, but those "correct"

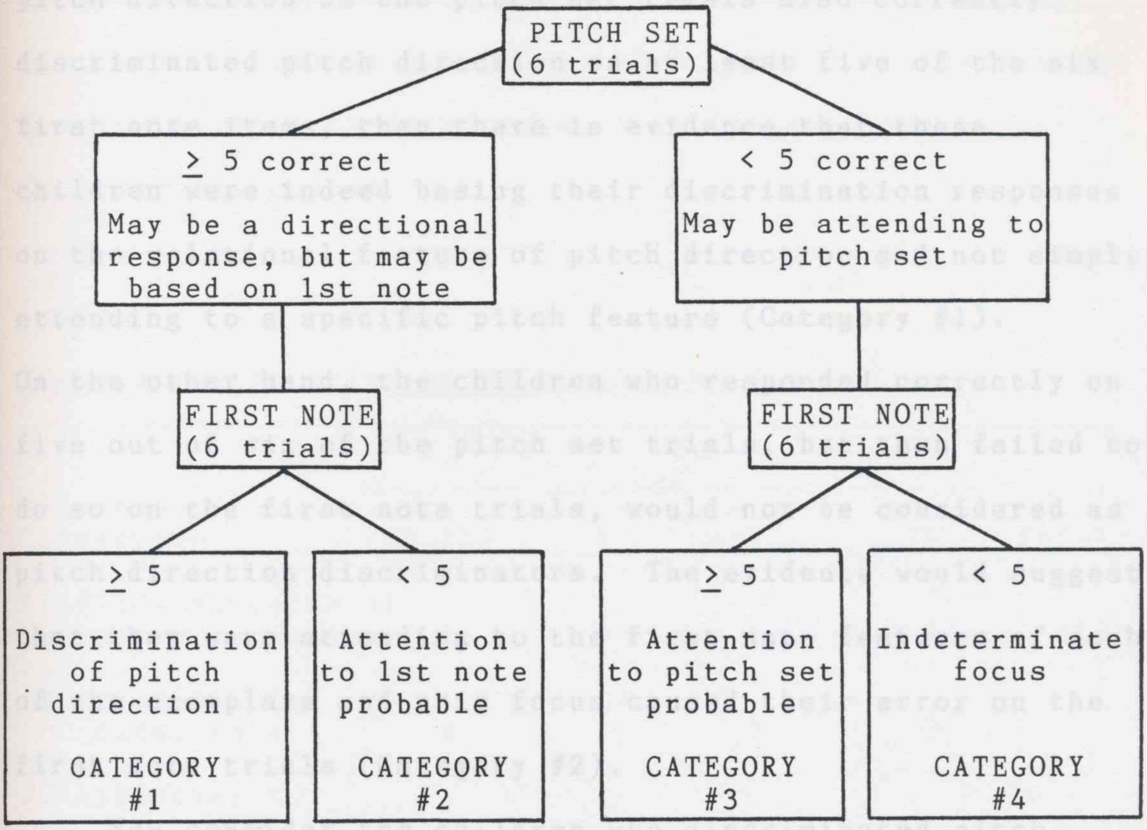

Figure 3.1. Discrimination response profile analysis.

responses could also have been the result of attending only to the first notes of the exemplars. The exemplar that was different on the basis of pitch direction was also different on the basis of only the first note (see Figure 2.6, trial 1). An examination of these children's responses to the six first note trials would give an indication of the basis of their response to the pitch set trials. If the children who appeared to have discriminated pitch direction on the pitch set trials also correctly discriminated pitch direction on at least five of the six first note items, then there is evidence that these children were indeed basing their discrimination responses on the relational feature of pitch direction and not simply attending to a specific pitch feature (Category #1). On the other hand, the children who responded correctly on five out of six of the pitch set trials, but then failed to do so on the first note trials, would not be considered as pitch direction discriminators. The evidence would suggest that they were attending to the first note features of each of the exemplars and this focus caused their error on the first note trials (Category #2).

Now consider the children who discriminated pitch direction on less than five out of six of the pitch set trials. Their difficulty with this task might have been due to their focus upon the set of pitches being used. These children's responses to the six first note trials would clarify if that is a possibility. If these children seemingly discriminated pitch direction on at least five out of the six first note trials, while failing to do so on the pitch set trials, then their attention to the set of pitches instead of the direction of the pitches would be confirmed (Category #3). The children who scored less than five out of six correct on both pitch set and first note trials do not provide evidence of any clear-cut strategy for their responses (Category #4). Table 3.1 presents the results of this discrimination profile tabulated by the four age categories.

Table 3.1

Discrimination Response Categories by Age

Response Categories	Age 3-1/2	4	4-1/2	5	Total
#1 Discrimination of pitch direction	1	5	6	19	31
#2 Attending to first note	2	1	3	0	6
#3 Attending to pitch set	4	4	2	1	11
#4 Indeterminate focus	7	8	6	3	24
Total	14	18	17	23	72

These figures indicate that 43% (31) of the total tested were able to focus on the relational attribute of pitch direction regardless of the absolute feature represented by the stimulus, but that 24% (17) of the children did reveal a tendency to focus on one of the absolute features. This latter figure was obtained by combining the data for the two absolute features, Categories #2 and #3. An interesting result of this profile analysis was the large number of children who did not meet the criteria to be identified as having either a relational or an absolute perceptual focus. One-third (24) of the children fell into this "indeterminate" category. Placement in this response category does not preclude the possibility that both absolute features were affecting their performance and that many of these children could be legitimately considered absolute-focus discriminators. It is equally possible that these "indeterminate" children were responding randomly to these discrimination trials and had no perceptual strategy at all. The design of this study does not allow for a definitive conclusion.

Hypothesis 1. To test the hypothesis that older children will discriminate pitch exemplars on a relational basis rather than an absolute one, a Chi-square test of statistical significance was used to determine if a systematic relationship existed between the three response profiles (relational, absolute, indeterminate) and the four age categories. Data for this test were presented in Table 3.1. The relational profile is equivalent to response Category #1; the absolute profile is a combination of Categories #2 and #3; the indeterminate profile is the same as Category #4.

The Chi-square test evaluates the differences between the observed and the expected frequencies in each of the cells of the matrix created by the two variables. The expected frequencies are detemined by the probability that there is no association between the variables and that they are, in fact, independent of each other. If this age-related hypothesis were true, there should be more older children and less younger children in the relational response category. This hypothesis was strongly supported by the results. A Chi-square (df = 6, N = 72) of 24.64, significant at p=.0004 indicates that these two variables, age and response category are systematically related.

A strong relationship between age and perceptual focus is evident from the data reported in Table 3.1. While 83% (19) of the 5-year-olds clearly focused on pitch direction, only 7% (1) of the 3-1/2-year-olds did so. Conversely, while 43% (6) of the 3-1/2-year-olds focused on an absolute feature, only 4% (1) of the 5-year-olds did so. Even in the face of feedback that would guide their perceptions to the relational feature of pitch direction, a number of the younger children revealed a definite tendency to focus upon an absolute feature that was present in the aural stimulus. Considering the possibility that many of the children in the indeterminate category were actually bothered by both absolute features, then the data would overwhelmingly support the theory that younger children tend to focus on absolute features, while older children focus upon relational ones.

Besides examining the categorical data obtained from the discrimination profile analysis, a two-way multivariate analysis of variance was performed. This was done to examine the between-subjects factor of age, the within-subjects factor of stimulus feature (first note and pitch set), and the interaction between the two. The dependent measure was the discrimination score with a maximum score of 6.00 possible for each type of stimulus. Table 3.2 lists the means for these factors and Table 3.3 provides the MANOVA summary.

Table 3.2

Discrimination Score Means

		Stimulus Feature		
Age	n	First Note	Pitch Set	Total Score
3-1/2	14	3.86	3.57	7.43
4	18	4.33	4.06	8.39
4-1/2	17	3.94	4.35	8.29
5	23	5.52	5.13	10.65
Total	72	4.53	4.37	8.90

Table 3.3

MANOVA Summary of Discrimination Scores

Source	SS	df	MS	F	p
Between Subjects					
Within Cells	182.23	68	2.68		
Age	55.93	3	18.64	6.96	.0001
Within Subjects					
Within Cells	55.03	68	.81		
Stimulus Feature	.64	1	.64	.79	.376
Age by Stim. Feature	3.63	3	1.21	1.49	.224

This analysis provides further evidence that age is a significant factor in children's pitch direction discrimination scores. To determine the source of significant difference among the four age categories, the Newman-Keuls multiple comparison test was utilized. A critical difference greater than 1.64 would indicate a pair of means significantly different at the .05 level. Table 3.4 provides this analysis with the means listed in rank order, rather than in chronological order.

This test indicated that the discrimination performance of the children in the three youngest age categories was not significantly different. Only children in the oldest category performed the task significantly more accurately than children in the three younger age

Table 3.4

Significance of Difference for Age
Newman-Keuls Multiple Comparison Test

Age Group	Mean	3-1/2	4-1/2	4
3-1/2	7.43			
4-1/2	8.29			
4	8.39			
5	10.65	*	*	*

* significant at $p < .05$

categories. In spite of this fact, the data did represent a significant linear trend, $p = .0001$. The effect is displayed in the graph of the four age-group means presented in Figure 3.2.

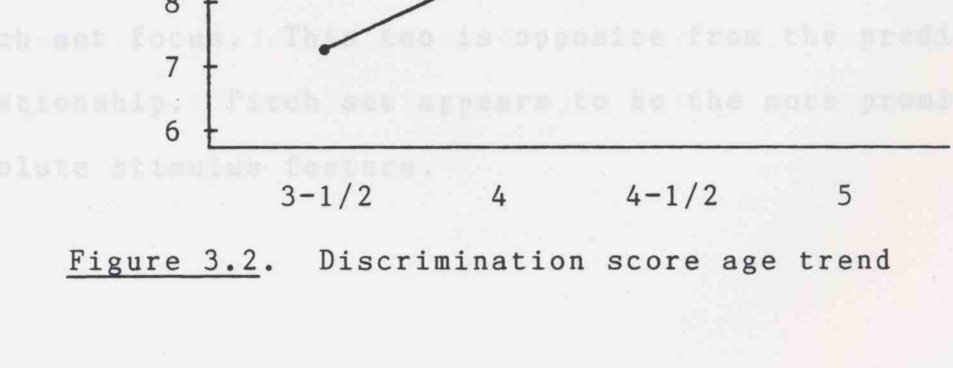

Figure 3.2. Discrimination score age trend

Hypothesis 2. The second hypothesis stated that children will perform more accurately on the pitch set discrimination trials than on the first note discrimination trials. This was derived from the theory that the first note feature would be more salient and therefore cause more errors in the discrimination of pitch direction on first note trials. As seen in Table 3.2, the data do not support this prediction. The scores were actually slightly higher on the first note trials (4.53 out of a possible 6.00) as compared to the pitch set trials (4.37 out of a possible 6.00), but this difference was not statistically significant (see Table 3.3). There was also no significant interaction between age and these two stimulus features. The significant difference in the discrimination scores that was due to age was not related to any shift in discrimination ability for these two types of trials.

Likewise, the discrimination response profile analysis (see Table 3.1) did not support this stimulus feature theory. While six children were identified as having a first note perceptual focus, 11 were classified with a pitch set focus. This too is opposite from the predicted relationship. Pitch set appears to be the more prominent absolute stimulus feature.

Categorization Test

Sixty-nine of the 72 children who participated in the discrimination phase of this study continued as participants in the categorization phase. The data obtained in this final phase were raw scores on a 12-trial categorization test. Each trial of the categorization test used three different exemplars thus providing the child with three different response choices. In a given trial, two of the exemplars shared a common pitch direction, two shared the same first note, and two shared the same pitch set. It was assumed that the choice of the "different" exemplar would imply attention to the common feature shared by the other two. Thus there were three distinct response categories: pitch direction, first note, and pitch set.

Hypothesis 3. The first hypothesis for the categorization data stated that older children would categorize the exemplars more on the relational basis of pitch direction while younger children would categorize more on the basis of the absolute features of first note or pitch set. The means of the scores for each age group by the three response categories are listed in Table 3.5. Due to fatigue, two of the 3-1/2-year-olds failed to respond to the 12th trial. This caused the sum of means for that age group to be slightly under the total score of 12.

Table 3.5

Categorization Score Means

		Response Category			
Age	n	Pitch Direction	Pitch Set	First Note	Total
3-1/2	14	3.93	5.14	2.79	11.86
4	17	4.71	4.82	2.47	12.00
4-1/2	15	4.47	4.33	3.20	12.00
5	23	4.44	5.17	2.39	12.00
Total	69	4.41	4.90	2.67	11.97

Because each child who completed all of the trials scored a 12 on the categorization test, the age effect had to be analyzed independently within each response choice category. A multivariate analysis of variance was performed for each of the three response categories. The dependent variable was the number of trials categorized according to that response choice; the independent variable was age. According to these analyses, chronological age was not a significant factor ($F < 1$). None of the three types of categorization scores varied significantly according to age. There was also no age by response category interaction ($F < 1$).

To determine if there was a significant difference in the categorization responses within each age group, another multivariate analysis of variance was performed on the categorization score means (see Table 3.5). This analysis tested for significant differences between the three dependent variables--pitch direction, pitch set, and first note, within each of the four age groups. There was a significant difference in the three types of categorization scores for the 3-1/2-year-olds, $F(2, 12) = 6.70$, $p = .01$; the 4-year-olds, $F(2, 15) = 9.91$, $p = .002$; and the 5-year-olds, $F(2, 21) = 15.92$, $p = .0001$; but not for the 4-1/2-year-olds, $F(2, 13) = 1.06$, $p = .373$.

To determine the source of the significance between the means within these three age groups, three pairwise contrasts of the means were examined: pitch direction with pitch set, pitch set with first note, and first note with pitch direction. All of the significant differences between the categorization scores within any age group were related to the especially low scores for first note categorizations. There were no significant differences between the means of the pitch direction (relational) categorizations and the pitch set (absolute) categorizations for any age group. In other words the older and the younger children's categorization choices were highly similar and not distinctly different as the hypothesis had predicted.

The hypothesis that older children would tend to categorize pitch exemplars on a relational basis according to pitch direction, and younger children would tend to categorize pitch exemplars on an absolute basis according to either pitch set or first note features was not supported by these data. There was very little difference in the categorization scores that could be attributed to age.

Hypothesis 4. The second hypothesis for the categorization test stated that there would be more categorizations based on first note features than on pitch set features. The means of these two categorization choices did not support this hypothesis. The mean for the first note categorizations was 2.67; the mean for the pitch set categorizations was 4.90. The difference between the means was statistically significant, $F(1, 65) = 32.94$, $p = .0001$.

While there was a significant difference between the number of trials categorized by pitch set and the number categorized by first note, the difference was in the opposite direction from that predicted. As in the discrimination phase, the pitch set feature was apparently more salient than the first note feature.

Although the categorization data was analyzed for age effects and stimulus feature differences, in reality the group scores across the four age categories for the three types of responses were at or near chance levels. An examination of the individual scores was necessary to determine if any children were able to categorize the exemplars in a consistent manner. A statistically significant score occurred if one of the three categorization possibilities was chosen on at least 8 out of the twelve trials (p = .018).

The ability to categorize aural exemplars in a statisically significant manner was not age-related. Table 3.6 lists the number of children whose scores revealed a possible categorization strategy.

Table 3.6

Categorization Strategy by Age

Age	Strategies: Direction	Pitch Set	First Note	Total
3-1/2	1	1	0	2
4	2	3	0	5
4-1/2	1	2	0	3
5	1	2	0	3
Total	5	8	0	13

Thirteen (19%) of the 69 children tested responded to the categorization test in such a way that a categorization strategy was revealed. These results indicate that this ability was not age-related since children from all four age groups are represented. This analysis also highlighted the salience of the pitch set feature in the categorization task. Although feedback was being given to direct the child's attention to the relational feature of direction, more children revealed a categorization strategy based on the pitch set feature, and none chose to categorize on the basis of the first note feature.

It is important to note that five children, representing the total age range, were able to focus on the relational feature of pitch direction. Considering the complexity of the task, this is quite remarkable and contradicts the general notion of preoperational children being unable to focus on abstract, invariant relations present in a stimulus complex.

The difficulty that the children had with the categorization task is evidenced by the large number (56) of them who revealed no statistically significant categorization strategy. It is possible that these children were shifting perceptual focus and really demonstrating a high level of conceptual ability by being able to categorize on any one of the features. It is also possible that 12 trials were not sufficient to reveal a definite strategy. However, it is far more reasonable to assume that these children were confused by the complex task and developed no obvious strategy to deal with the situation. Twenty-one of these 56 children had been identified as pitch direction discriminators in the prior phase of the study. That they responded in an indeterminate way to the categorization task speaks to the complexity of the task and the confusion that arose from the conflict of the pitch set salience with the pitch direction feedback.

Secondary Effects

Besides the variables that were the major focus of this research, there were some secondary features inherent in the design and implementation of this study that warranted attention. These factors were not a part of the original statistical analyses for two reasons. First, there were no theory-derived hypotheses to be tested, and secondly, multiple variables reduce cell sizes and significantly weaken the power of the test. The data concerning these additional stimulus, design, and participant factors will now be presented.

Direction. The direction of the melodic pattern was an inherent factor in the design of the aural stimuli for this pitch direction study. In each trial in both the discrimination and categorization tests there were either two ascending exemplars with one descending or two descending exemplars with one ascending. On each test six trials were identified as ascending and six trials were identified as descending according to the direction of the "different" exemplar. The means of these ascending and descending sets of trials were compared to determine if the direction variable influenced the child's response. These means are presented in Table 3.7.

Table 3.7

Direction Effect Means

		Direction	
Test	n	Ascending	Descending
Discrimination	72	4.46	4.44
Categorization	69	1.96	2.45

As the nearly equivalent means indicate, the discrimination of pitch direction was not dependent upon the directional feature of the "different" exemplar, $t(71) = .09$, $p = .93$.

The categorization scores did show a significant effect as a result of direction. While pitch direction was not the most popular basis for categorization, the children did respond to the pitch direction categorization more frequently when the different response was a descending exemplar than when it was an ascending one and this difference was significant, $t(68) = -2.32$, $p = .023$. This could indicate that when the direction of the "different" one is a descending pattern, the feature of pitch direction is more salient. It could also indicate that when the task is more complex, the influence of other features is more apparent.

Screen Display. One of the variables introduced by the design of this study was that of the screen display used for each trial. In both the discrimination and categorization tests, the three aural exemplars appeared in four different and randomly distributed visual configurations: the A-shape, the V-shape, the Upper Line, and the Lower Line. These were described in Chapter 2 (see Figure 2.2). In the discrimination test the screen displays were counterbalanced with the other features of the design so that a perfect score of 12 would result in a score of 3 for each screen display. The discrimination score means for each of these screen displays are listed in Table 3.8.

Table 3.8

Discrimination Test: Screen Display Score Means

	Age Groups				
Screen Display	3-1/2	4	4-1/2	5	Total
A-shape	1.64	1.94	2.06	2.65	2.14
V-shape	1.57	2.11	2.12	2.61	2.17
Upper Line	2.14	2.28	2.06	2.74	2.38
Lower Line	2.07	2.06	2.06	2.65	2.25

A multivariate analysis of variance was done to see if to see if there was any effect due to screen display, or any interaction with screen display and age. The discrimination scores for each screen display served as the dependent measures. No statistical significance was found for either of these effects: screen display, $\underline{F}(3, 66) = 1.84$, $\underline{p} = .149$; age by screen display interaction ($\underline{F} < 1$).

Likewise, in the categorization test the screen displays were counterbalanced with the other features so that a child who categorized all 12 trials on the same basis would have a score of 3 on each of the screen displays. The effect of this screen display variable upon the pitch direction categorization scores was also examined. Table 3.9 presents the pitch direction categorization means for each of these screen patterns.

Table 3.9

Categorization Test: Screen Display Score Means

Screen Display	Age Groups 3-1/2	4	4-1/2	5	Total
A-shape	1.29	1.23	1.20	1.13	1.20
V-shape	.64	1.23	1.20	1.26	1.12
Upper Line	.86	.82	.87	.74	.81
Lower Line	1.14	1.41	1.20	1.30	1.27

A multivariate analysis of variance was also performed with the categorization data to test for any effect due to screen display, or interaction with screen display and age. The dependent measures were the pitch direction categorization scores for each screen display. No age by screen display interaction was evident ($F < 1$), but there was a significant difference in the scores due to screen display, $F(3, 63) = 3.99$, $p = .011$.

The source of this significance was the difference that existed between the Upper Line scores and the scores on the three other screen displays. A closer examination of the data revealed an oversight in the test design that explains this difference. Although the left, middle, and right response positions were counterbalanced across the twelve trials, these three response positions were not counterbalanced within two of the four screen displays. The Upper Line pattern had two right and no middle response positions for pitch direction and the Lower Line pattern had two middle and no right response positions for pitch direction. The difference in the screen display means can be attributed to this discrepancy in the design. This result will be further explained as the effect of response position is presented in the next section.

Response Position. The computer program for this study was designed with six possible response sectors available on the monitor, a left, middle, and right position in both the upper and lower half of the screen. With only three exemplars occurring per trial, each trial offered a left, middle, or right response position choice presented in one of the four screen displays previously described (see Figure 2.2).

In the discrimination test, the correct response was equally distributed across these three left, middle, and right response position possibilities. A perfect score on all 12 discrimination trials would result in a score of 4 for each left, middle, and right response position. In the categorization test there was no "correct" response, but the design was counterbalanced so that if a child was consistent in any one of the three categorization choices, again the expected response profile would be a score of 4 for each left, middle, and right response position. The means for these three response positions for both tests are listed in Table 3.10.

Table 3.10

Response Position Means

Test	Left	Middle	Right
Discrimination	3.85	3.93	4.21
Categorization	3.25	4.80	3.93

In the discrimination test there was a slight bias for the right response position, but this was not statistically significant, ($F < 1$). In the categorization test there was an even greater tendency to choose the middle response position and a statistical analysis revealed that the position effect for this test was significant, $F(2, 64) = 5.89$, $p = .004$. Tests of the differences between the three pairwise contrasts -- left with middle $F(1, 65) = 11.92$, $p = .001$; middle with right $F(1, 65) = 4.39$, $p = .04$; and left with right $F(1,65) = 2.07$, $p = .155$, indicated that the middle score was significantly different from the other two, but that the left and right scores were not significantly different from each other.

It was thought that the tendency toward a right position bias in the discrimination test might be attributed to a left-to-right touching order, with the child then tending to respond to the last item touched. A videotape analysis of 26 discrimination testing sessions quantified the touching order strategies. Thirteen (50%) of the 26 reviewed did prefer a left-to-right order, using that on at least eight of the 12 trials. Eight preferred a right-to-left order, and five displayed a random touching order. Another interesting element noted in this review of the touching order was that between trials some children would switch from using the right hand for touching the exemplars to using the left hand, and some would even switch hands within trials. Because of the great variety of touching strategies, and the factor of handedness, it was impossible to quantify a direct link between touching order and response position. However, since 50% of those children reviewed did prefer the left-to-right touching order, this could account for the slight right position bias.

There is no viable procedural explanation for the shift from a slight right position bias on the discrimination task to a significant middle position bias on the categorization task since the same four screen displays were used in both tests. Twenty-one categorization tests were reviewed for any clues to explain this happening. This analysis revealed that the touching order profiles for the categorization test remained about the same as those for the discrimination test. Thirteen of the 21 reviewed preferred the left-to-right touching order, 5 preferred right-to-left, and 3 used random orders.

Although most features remained the same in moving from the discrimination to the categorization phase, the one feature that changed was the test itself. The response position bias that occurred in the categorization test could have emerged due to the complexity of the test demands. There is plenty of evidence that the categorization task was by far more complex than the discrimination task. A child that was confused by the feedback and unsure of the appropriate response could have resorted to a response position based on convenience or preference rather than logic.

<u>Learning or Fatigue</u>. In comparing the scores on the first half of a test with the last half, it is assumed that if the scores on the last half decrease significantly, fatigue may be a factor. On the other hand, if the scores on the last half significantly increase, the child may be learning as the test proceeds. Table 3.11 presents the means of the first-half and last-half scores for the discrimination and categorization tests. Since there

were three correct ways to respond to the categorization test, the categorization data were analyzed accordingly.

Table 3.11

Learning/Fatique Effect Means

Test	First Half	Last Half
Discrimination	4.49	4.42
Categorization of Pitch Direction	2.20	2.20
Categorization of Pitch Set	2.38	2.52
Categorization of First Note	1.14	1.25

Neither learning nor fatique appear to have been a factor in the children's performances on these tests. There was no significant difference between the scores on the first half and the last half of either the discrimination or the categorization tests. Feedback was given in both tests to direct the attention of the child toward the feature of pitch direction, but the data indicate that this had no appreciable effect on the scores. Individual scores did provide evidence that the feedback assisted a few children in focusing their attention on pitch direction. However, there were as many that showed no effect, or even a change in the opposite direction from the feedback given.

Sex. Sex differences are not a critical issue for this age group with this type of test. No significant differences between the sexes were predicted and none were obtained on either the discrimination test, $F(1, 71) = .131$, $p = .719$; or the categorization test, $F(3, 65) = 1.21$, $p = .313$. The mean scores by sex for both tests are presented in Table 3.12. Only the first note scores in the categorization test were approaching a significant difference due to sex ($p = .058$).

Table 3.12
Sex Effect Means

Test		Sex: Boys	Sex: Girls
Discrimination	n	36	36
Pitch Set		4.25	4.50
First Note		4.56	4.50
Categorization	n	33	36
Pitch Direction		4.21	4.58
Pitch Set		4.73	5.06
First Note		3.03	2.33

CHAPTER 4

DISCUSSION

This study examined the ability of preschool children to discriminate and categorize three-note pitch exemplars on the basis of pitch direction. The effect of age as well as the effect of first note and pitch set stimulus construction were of primary concern.

The Developmental Factor

Discrimination. Cognitive developmental theory supports the hypothesis that young children's cognitive abilities improve with age. The results of the discrimination test support this hypothesis. Age was a primary factor in the discrimination scores, but the age and score relationship was not monotonic. Discrimination scores for the three youngest age groups were at about the same level, but there was a substantial increase in the scores of the 5-year-olds. This marked difference in discrimination performance ability is indicative of a qualitative, Piagetian-type change in cognitive functioning.

Piaget and Inhelder (1969) proposed a cognitive-developmental theory that was concerned with the nature of the mind and the acquisition of knowledge. He identified four invariant stages of cognitive development, and proceeded to provide evidence of children within each developmental stage thinking and responding to various tasks in qualitatively different ways. According to his theory, a sudden increase in cognitive performance, such as the one that occurred on the discrimination task, could be indicative of a change in cognitive structure, a change in the way a child thinks about a certain task.

One of the controversies surrounding cognitive-developmental theory today concerns the existence and development of these cognitive structures. Are there global cognitive structures that exist across diverse domains such that the structure of thought is the same for all types of knowledge? Or, as some have proposed, are there separate cognitive structures, each with its own developmental sequence, for various domains of knowledge (Gardner, 1983; Hargreaves, 1986; Hildebrandt, 1987). If one assumes that Piagetian theory, which deals primarily with the domain of physical and logical-mathematical thinking, applies to all domains of knowledge, one would expect that as these cognitive-developmental stages occur, they would affect cognitive behavior in all domains. This would lead one to expect similar cognitive behavior within the age range for each developmental stage on various types of cognitive tasks.

Piagetian theory does not predict a significant difference in the cognitive performance of 3-, 4-, and 5-year-olds, since children of these ages are all considered to be within the preoperational stage. However, there have been studies with innovative testing procedures, such as those by Donaldson (1978) and Gelman and Meck (1983), that have reported higher levels of cognitive functioning with preschool children than Piaget's preoperational stage theory allows.

A significant difference did occur in the discrimination performance between the 5-year-olds and the three younger age groups in this study. Could this be an indication that music cognition develops according to a different chronological timetable than that delineated by Piagetian theory, or is this simply another indication that if given an appropriate task, young children are more cognitively competent than Piaget's theory proposes?

Although the age effect is obvious from the group data, a closer look at the individual scores provides some further insight. The group data imply that younger children do not discriminate pitch direction as well as older children, and in general this is true. However, there are several individual instances that clearly contradict this general finding. For instance, a child as young as 45 months discriminated pitch direction with a score of 11 correct out of a possible 12, while a 61-month-old child scored only at a chance level of 6 out of 12. As with many other cognitive processes, chronological age is an important factor in pitch direction discrimination ability, but it is not the only one affecting the score. There is ample evidence for variability in pitch direction discrimination performance due to both development and individual differences.

There are many things that could have an impact upon a child's ability to perform any cognitive task. Genetic factors, environmental circumstance, general intelligence, personality, attention and memory capacities, cognitive strategies, and many more contribute to a child's performance. Factors such as these are assumed to be randomly distributed in a sample, but are acknowledged as possible contributors when great differences in individual scores are noted.

It was also theorized that some children would have difficulty discriminating the relational attribute of pitch direction due to their focus on an absolute feature of the stimulus. This perceptual focus was thought to be age-related with older children tending to discriminate the pitch exemplars on the relational basis of pitch direction, while younger children would tend to discriminate more on the basis of absolute features. The two absolute features tested were first note and pitch set. The results of a Chi-square analysis indicated that indeed the relationship between age and perceptual focus was highly significant. While most 5-year-olds were able to discriminate the relational concept of pitch direction, many of the younger children could not. For instance, 61% (19 of 31) of the pitch direction discriminators were 5-year-olds; only 6% (1 of 17) of those focusing on absolute features were from this oldest age category. Likewise, while only 3% (1 of 31) of the pitch direction discriminators were 3-1/2-year-olds; 35% (6 of 17) of those focusing on absolute features were from this youngest age category.

These findings support the theory that perceptual focus is age-related. This theory needs to be further investigated with the concept of pitch direction as well as applied to many other aural concepts.

Categorization. In this phase of the study, children were given the opportunity to categorize three-pitch exemplars on the basis of pitch direction, pitch set, or first note features. It was predicted that older children would categorize more on the relational basis of pitch direction, while younger children would catgeorize more on the basis of one of the absolute stimulus features.

In developing the age theory for the categorization test, it was assumed that if age was a factor in the discrimination of pitch direction, as had been reported by Webster and Schlentrich (1982) and White (1983) in their studies with preschool children, then age would also be a factor in the categorization of pitch direction. This theory was not supported by the categorization data. Only 5 of the 69 childen showed a significant tendency to categorize on the basis of pitch direction, and with these five children all four age categories were represented.

One could perhaps assume from the results of this test that children between the ages of 3-1/2 and 5 are within the same cognitive stage when it comes to categorizing aural stimuli on the basis of the pitch concepts featured in this study. Most were, in fact, unable to deal with the complexities of this aural categorization task at all. However, since 81% (56) of the children's scores were at or near chance levels, it is highly likely that a floor effect was obtained and that the age differences which probably do exist in young children's ability to categorize aural stimuli were not addressed in this test.

These data do indicate that the ability to discriminate on the basis of a certain stimulus feature and the ability to categorize on the basis of that same feature are two distinct processes. Although only 5 children out of 69 were able to categorize pitch direction exemplars, 31 of these same children had been able to competently discriminate pitch direction in the earlier phase of the study. While the discrimination process of identity and distinction between three aural exemplars can readily be accomplished by many young children, the categorization process of feature extraction and recognition of commonality between distinct aural exemplars is extremely difficult.

The demands of an aural categorization task are particularly complex. When faced with a visual categorization task, the objects are generally all present and immediately visible. Visual memory is usually not tested since the stimulus features of the objects to be categorized remain in view. With aural stimuli, the categorical similarity must be heard. The common feature must be extracted from the musical event by remembering the distinct features of one exemplar and comparing them to another. This complex task requires a great deal of aural feature extraction and aural memory.

In spite of these complexities, discrimination and categorization paradigms offer important means for investigating children's understanding of music concepts. While there are many studies concerning children's aural discrimination abilities, it is strongly recommended that more studies incorporate the categorizaton model. It is also suggested that in order to more thoroughly address music concept development, more studies need to include children whose ages range from preschool through the early elementary grades. When a study's lower age limit is kindergarten children the findings generally report a lack of competence on a certain task by these children. Preschool studies, such as this one, that have an upper age limit of 5-year-olds, generally report this age group more competent on the tasks under investigation. Music cognitive development literature needs studies of concept development that cross the age range from preschool into the early elementary grades to uncover important features of musical development that reside within those years.

The Stimulus Design Factor

The exemplars for both the discrimination and categorization tests used two absolute stimulus features, first note and pitch set. The first note feature was predicted to be more salient than the pitch set feature thereby causing more errors on the first note trials in the discrimination test and resulting in more first note choices in the categorization test. Contrary to the proposed hypotheses, the first note of the three-note pattern did not assume perceptual priority over the feature of pitch set in either the discrimination or the categorization test. In fact, the findings suggested just the opposite with pitch set proving to be more salient in both situations.

This first note theory was primarily derived from the evidence reported by Sergeant and Roche (1973) that the 3- and 4-year-olds in their study tended to have an absolute pitch focus and were thus far more accurate in singing the exact first pitch of a learned melody than were older children. Since the results of this current research do not lend support for a first note perceptual focus theory, it must be concluded that the perceptual focus used by young children in learning and singing an intact melody (Sergeant & Roche, 1973) is different from the perceptual focus that emerged when three-pitch exemplars were listened to and compared for commonality.

In the discrimination test 24% (17 of 72) of the children displayed an absolute focus; 11 attended to pitch set, and 6 attended to first note. In the categorization task more trials were categorized on the basis of the absolute feature of pitch set than either the relational feature of pitch direction or the other absolute feature of first note. The categorization results especially support the Piagetian view that the reasoning of preoperational children is more perceptually controlled. Just as Piaget would have predicted, the young child focused on an absolute feature of the event, and because of this, failed to detect the more abstract invariant relations that were present in the stimuli.

While the perceptual priority of pitch set over the two other features in the categorization test may be attributed to the child's being in the preoperational stage of cognitive development, the factor of perceptual salience must also be considered. An object or event is most often a combination of many features. Perceptual salience refers to that feature of the stimulus that is perceived to be the most prominent by the perceiver. Odum (1978) and Odum and Cook (1984) have explored this idea of perceptual salience with objects, using such features as size, color, and orientation. They have concluded that there are developmental increases in perceptual sensitivity that result in a hierarchical organization of perceived features, and that these sensitivity or salience hierarchies do have an influence on the outcome of certain conceptual tasks. They have concluded that the relational features that exist among stimuli can be attended to if they are made to be highly salient. Perhaps similar salience hierarchies exist in aural stimulus processing. The findings in this study suggest that this is the case. The musical stimulus offers many features from which to explore the idea of perceptual salience. Besides pitch features such as direction, first note, pitch set, interval, contour, and diatonic structure, there are also features involving aspects of duration, loudness, and timbre. Further research is needed to corroborate the findings of this study, and to further explore the theory of perceptual salience with various types of music stimuli. Issues such as the hierarchical order of different stimulus features and the developmental sequence of selective attention to these various features need to be addressed.

The literature on melodic processing provides some insight as to why the pitch set feature might be so highly salient (Dowling, 1988; Trehub et al., 1986) to the preschool child. Both of these melodic discrimination studies indicate that the young child is aware of diatonic structure and that this feature is an important part of their melodic perception. Since the two pitch set exemplars that appeared in each trial contained the same pitches, albeit one ascending pattern and one descending pattern, the child nevertheless experienced a repetition of those pitches and also a repetition of the same diatonic scale. This structural dimension may have served to provide further salience to the the pitch set feature. If the child was responding to the pitch set feature as a diatonic structure rather than an absolute set of three pitches, the child's focus could be judged relational rather than absolute. The relational feature would be diatonic instead of directional.

If the number of items to be remembered were part of the issue, it would seem that the three pitches involved in the pitch set might possibly be more difficult to remember by the young child than just the first note of each exemplar. One item, such as the first note, should be easier to remember than three. However, melody is one of those aural events that demonstrates our ability to chunk together diverse "parts" and create "wholes" that are greater than the sum of them. It is possible that a melody made up of several pitches is more easily retained in the memory than just certain isolated pitches. For this particular study, it could be that the set of pitches, the melodic gestalt, formed a more memorable unit for comparison than did just the first notes from the pitch patterns.

In the discrimination phase of this study 17 children (24%) were identified as having an absolute perceptual focus rather than a relational one. These tendencies emerged from only 6 trials of each type of stimulus construction. However, 24 children (33%) were unable to be classified as having a definite stimulus feature focus. Perhaps a replication of this discrimination test design that would permit more trials for each type of stimulus construction could provide more information about the perceptual tendencies of children this age.

The apparent salience of pitch set in the categorization task was confounded by the feedback given to direct the child's attention to pitch direction. It is interesting to speculate what the results of the categorization test would have been if the children had been allowed to respond to the trials according to their own perceptual strategy without any guidance toward a specific feature. It is possible that the results would have indicated an even stronger tendency to attend to the pitch set feature. It is also interesting to speculate what the results of this categorization test would be if older children or even adults, musically trained and untrained, were asked to perform the categorizations without being given any predisposition toward a certain feature. Would the relational concept of pitch direction emerge as the salient feature over the absolute feature of pitch set at a certain age? At what age, if any, would the participant be able to recognize that there are three possible ways to categorize the exemplars? The test design offers many possibilities for further study.

<u>Methodology</u>

<u>Instrumentation</u>. One of the goals of this research was to investigate preschool children's understanding of pitch direction without requiring them to respond to the aural stimulus with either verbal reference or some form of visual-spatial association. This was successfully accomplished by the use of the Touch Screen with the computer. The children were completely comfortable with the instrumentation and seemed to enjoy their interaction with the screen; no one hesitated to touch the pictures on the screen once they were given instruction to do so. Many were especially intrigued by their ability to control the aural stimulus.

An advantage of the Touch Screen was the ease with which the child could re-listen to any exemplar. This was an important feature since the task required a comparison of aural events. Videotapes were studied to judge how often this re-inspection option was utilized. Of 300 discrimination trials reviewed, 260 trials (87%) were responded to after the first inspection, 34 (11%) after the second, and 6 (2%) after the third. Of 252 categorization trials reviewed, 202 (80%) were responded to after the first inspection, 41 (16%) after the second, and 9 (4%) after three or more inspections. While the figures within each test are comparable, the slight percentage differences seen between tests are most likely due to the increased task difficulty. Although most children on most trials preferred not to re-listen, it was important to have the option available for those trials in which it was used.

One weakness that emerged from the programming of the Touch Screen for an aural task was the lack of consideration given to the child's touching pace. If a child failed to release the touch, the exemplar would continue to sound. If a child moved rapidly from one exemplar to the next, the second exemplar would not be activated because the first one was still being played. In both of these situations the child's touching pace had to be monitored and adjusted. This problem was primarily dealt with during the in-class familiarization phase and the demonstration trials that occurred before the individual tests.

The usefulness of the computer to early childhood education in general has been well-documented (Beaty & Tucker, 1987; Hoot, 1986). Its successful functioning in this research project suggests that the computer is also a powerful research tool for evaluating many aspects of early childhood music development. The Touch Screen could provide the non-verbal response mode necessary for research involving the discrimination and cateogorization of other music concepts, the association of aural stimuli with visual representations of those events, and the perceptual salience issues mentioned earlier in this chapter.

Visual stimuli. Access to the aural stimuli occurred via four different screen displays on the computer monitor. Circles and squares in various colors were used with these varying displays to provide interest and variety in the visual domain. Because the attention span of the young child is so limited, these patterns, shapes, and colors served to make the 12-trial tasks more interesting without distracting from the aural focus of the two tests. As an essential part of the test design, they fulfilled their function rather well. One child referred to the A-shape with squares as a house, and two children commented that the V-shape using circles reminded them of Mickey Mouse (It did resemble the Disney Channel logo.). Otherwise there was no evidence of any particular attraction to the visual input, that resulted in distraction from the aural.

The four screen display patterns not only maintained interest in the task, they also allowed for the six different response positions to be presented with visual variety. This was an important design feature considering the possibility of response position bias that often occurs when testing young children. Even with the varying screen displays, a significant preference for the middle response position was evidenced with the categorization task.

This was thought to have occurred due to the complexity of the aural task. The children perhaps resorted to a position strategy when no cognitive one was available. This tendency toward response position bias must always be kept in mind when designing procedures for testing young children.

Aural stimuli. The aural stimuli used in this study were three-note, uni-directional pitch patterns. The direction of the "different" one had no significant effect upon the discrimination scores, but it did produce significantly different results on the Categorization Test. There is very little evidence available regarding the effect of direction of melodic pattern upon the perceptions of very young children. Webster and Schlentrich (1982) reported that descending motion may result in quicker pitch direction perception since preschool children in their study scored slightly higher on descending items in an aural discrimination task. Hair (1977) in a study of pitch direction discrimination with first grade children, reported significantly higher scores on two- and three-note descending patterns than on ascending ones. In aural discrimination tests of pitch direction with participants ranging in age from 11 years to adult, Bentley (1973) reported that significantly more errors occurred on ascending items than on descending ones. He concluded that descending items are more easily discriminated. Further investigation is needed concerning the effect of melodic direction upon the perceptions of preschool children before any definitive conclusions can be drawn.

Data collection. The testing environment is very important for children of preschool age. For this reason the research was conducted at the children's preschool. All individual testing was done in a private room close to the regular classroom. While the environment was not always ideal in terms of noise level and convenience for the investigator, it was ideal for the children because they were in familiar and comfortable surroundings. The decision to begin the research with a get-acquainted day in the classroom was a wise one. This allowed time for the investigator to meet all of the children and through the normal routine of the classroom session, establish a relationship with each of them.

Each child participated in three individual tests. Jetter (1978) reported that the preschool children in her study were quite uncomfortable with the individual testing situation. This was not found to be the case in this study. The children displayed a high degree of interest in participating. Since the testing occurred as part of the regular preschool day during the "free-choice" time, the children were allowed the freedom to volunteer for their turn at the computer. Most often they were eager to volunteer; very few had to be told it was their turn to go play the computer music game.

The Visual Oddity Test served an essential role in the research design. Although the data represented a ceiling effect, it functioned as a non-threatening introduction to the computer and the testing routine. It also gave the children an opportunity to be highly successful and develop confidence in their first individual testing situation. As Donaldson (1978) has suggested, the social context of the test situation is closely linked with its cognitive content. It was very important in the early phase of the study to allow the children time to adjust to the investigator, the testing environment, and the instrumentation. The Visual Oddity Test accomplished all three of these objectives.

The Familiarization phase of the study also worked well. The computer was placed in the preschool classroom during free-choice time and the children were allowed to discover how to make the computer play music. The investigator monitored the computer's use and made sure that each child had access. After the initial demonstrations, the investigator only intervened when the children needed to be reminded to take turns. Many children returned for additional time with the computer; even the ones who were hesitant to join in at first, took their turns after watching for awhile.

The Discrimination Test pointed out the tendency of some young children to label individual exemplars rather than use words to refer to relationships that existed between those exemplars. Although there was confidence that the child understood the meaning of "same" and "different" from the Visual Oddity Test, the words "right" and "wrong", and "yes" and "no" were spoken by some of the children as the task was performed. The reference was always for two "right" exemplars and one "wrong", or two "yes" exemplars and one "no". The use of these words in this way seemed to indicate an identification strategy in which the child needed to have a label for each exemplar. While the child may have understood the concept of "same", the willingness to use this one word to describe a relationship between two separate events was not always evident. There was also occasionally the tendency to declare the second exemplar heard as being the "different" one, if it was in fact different from the first one heard. Again the concept of two events having the relationship of "same" was not the primary focus. These children had to be reminded to listen to all three exemplars before selecting the "different" one.

In all of the data collection activities, with 72 discrimination tests and 69 categorization tests, only one verbal comment was noted that referred to a directional aspect of the exemplars. This child pointed to the different exemplar and said, "That one was backwards." While no verbal response was solicited from the children in this study, the almost total lack of verbal reference to the aural stimuli heard by these children lends support to the research that has concluded that young children do not possess consensual labels for aural concepts, but that these must be learned (Hair, 1977; Van Zee, 1976).

There were five demonstration trials prior to the Discrimination Test, two visual, and three aural. All of these were necessary for training. Touching pace and the opportunity to relisten were two important aspects that were emphasized during the aural demonstrations. Twelve items on the actual test were an appropriate number in terms of the length of session and the attentiveness of the child.

On the Subject Data Sheet for the Discrimination Test, 20 children were noted as being especially patient to relisten, and intent upon performing the task accurately. At the same time, 13 were noted for their inattentiveness or boredom, while 5 were noted for response impulsivity.

The Categorization Test as it was designed for this study was too complex. Although each exemplar was different, any two could be categorized on the basis of some common feature. Most children tended to focus on the feature of pitch set. It was confusing for these children when the investigator gave feedback to direct their attention toward pitch direction. While the results indicate that even in this complex setting, some young children could categorize aural stimuli, it is strongly recommended that a much simpler design be developed to test this ability in preschool children. A design that had only one distinct basis for categorization, with each trial having only one "correct" answer, would be much more practical for testing this age group.

It is also recommended that if a discrimination and categorizaton test format is used, a visual categorization training task be inserted in between the aural discrimination and categorization phase of the study. With the Visual Oddity Test and the subsequent Discrimination Test, the children were perhaps predisposed to expect two exemplars to be identical and one to be different in all trials. With only one trial of aural categorization training, the sudden change to a categorization paradigm could have been disconcerting. Not only was this task more complex perceptually; it was also more complex conceptually. With a visual cateogization task provided, the children could have been given the chance to grasp the concept of different, yet same, that is necessary for successful categorization.

After three separate individual testing days, the children had not reached a saturation point for participating in the study. Many expressed disappointment at not being able to continue. This suggests that a longitudinal design using many of the procedures incorporated in this study would be feasible.

Feedback. Since this study was designed to evaluate children's understanding of pitch direction, feedback to direct the child's attention to that feature was incorporated as an important part of the design. As explained in Chapter 2, this decision was based on the findings of Gelman (1969) who tested kindergartners on a oddity task with and without feedback. She found that it was important to direct the young children's attention to the appropriate focus. Otherwise they did not understand that there was a correct response and thus did not perform well on the task.

The purpose of the study was not to "train" young children to perform a discrimination or categorization task and then judge the effectiveness of those training procedures. The feedback was provided so that the children who were capable of focusing on the relational concept of pitch direction would be encouraged to do so. In other words, the feedback did not teach a child to discriminate or categorize, it only served to direct their attention to the intended perceptual focus. If they were capable of performing these cognitive functions, the feedback would facilitate them. If, however, they were not capable of discriminating or categorizing aural stimuli in this way, the feedback would be meaningless. The question to be answered with this study was not what were young children capable of learning, but rather, when presented with certain tasks, what were they already capable of doing? Supporting this contention, there was no evidence that the feedback produced any learning effects when the scores on the first half and last half of both the Discrimination and Categorization Tests were compared.

The feedback functioned appropriately in the discrimination task where there was only one correct response: two exemplars were identical, one was different. The feedback highlighted this condition. However, the feedback in the categorization task did not work as well, since there were three possible ways to correctly categorize the exemplars.

The feedback in the categorization task attempted to direct attention to the pitch direction feature, even though this was not the only common feature present.

It was assumed that because all of the children had just participated in a pitch direction discrimination test during the previous week, many of them would already be predisposed to attend to the pitch direction feature in the categorization task. This did not prove to be true. The feature of pitch direction was not easily extracted from the set of exemplars even by those children who had demonstrated a high level of pitch direction discrimination ability.

The assumption was wrong that pitch direction would be the most salient feature of the categorization stimuli. The most readily perceived feature among the three presented was pitch set. When the feedback contradicted the perceptual focus, the result was often confusion and frustration. At least 10 of the children verbally contradicted the feedback, while others extended their relistening strategies trying to find the correct response. As was mentioned earlier, this categorization study needs to be replicated with the feedback component eliminated. The results could then address the perceptual priority of the features of pitch direction, first note, and pitch set without the confounding of feedback that highlights one feature over another.

Summary and Implications

This research attempted to find a possible cause for young children's difficulty with the aural relational concept of pitch direction. It was theorized that the difficulty could be attributed to the young child's tendency to focus upon absolute rather than relational features of a stimulus. The results suggest that this is indeed a possible explanation for some children. Some children in both the discrimination and the categorization task were identified as having an absolute feature focus.

In pitch direction discrimination studies with 4- and 5-year-olds, Webster and Schlentrich (1982) found that 34% of the children tested could not discriminate pitch direction and White (1983) found that 38% could not. As their results led this investigator to the theory development for this current research, their reported successes became suspect due to their stimulus designs. The absolute features of first note and pitch set could have confounded the children's responses to the relational feature of pitch direction in both of those studies.

Keeping in mind the fact that a six-month younger age range was involved in this current research, 43% of the children were identified as pitch direction discriminators, 24% were found to be attending to absolute features, and 33% were unable to be identified as to their perceptual focus. These results agree with the findings of the earlier studies that some young children have difficulty with this relational concept. It is interesting to note that even with the new technology that allowed for a direct non-verbal, non-visual-spatial response, a large percentage of these young children still were unable to provide evidence of pitch direction discrimination. The question remains as to whether this inability is the result of methodology or cognitive deficit.

At the same time these new findings indicate that 24% of the children were focusing on a stimulus feature other than pitch direction. With no control over absolute stimulus features, the possible confounding of the results of the two earlier pitch direction studies with preschool children (Webster & Schlentrich, 1982; White, 1983) must be acknowledged. The possibility that the young child will focus upon absolute stimulus features must be taken into account when designing stimuli and interpreting findings for both research and educational purposes.

While the Morrongiello et al. (1985) study has indicated that preschool children attend more to the relational feature of contour while ignoring specific pitches, other studies have indicated that many young children have considerable difficulty discriminating or categorizing pitch exemplars on a relational basis whether that basis was direction (Webster & Schlentrich, 1982; White, 1983) or contour (Scott, 1977). The findings of this research, that 57% did not discriminate pitch direction and 93% did not categorize this relational feature, provide further contradiction to the conclusion of Morrongiello et al. (1985) that young children focus on relational over absolute features.

It should be noted that the studies that reveal both infants' (Chang & Trehub, 1977; Summers, 1984; Trehub, Thorpe, & Morrongiello, 1987) and young children's (Morrongiello et al., 1985) relational response to melodic stimuli are those that utilize the paradigm of a conditioned response to a recurring background pattern. In this situation where one standard melodic stimulus occurs repeatedly, infants and young children are apparently capable of attending to the relational contour information that is present in that recurring stimulus and then comparing subsequent exemplars to that standard. This is not to say, however, that the young child is able to independently extract that same relational feature when confronted with a variety of pitch exemplars, none of which is being constantly repeated. In other words when no standard melodic pattern exists for direct comparison, young children perhaps have greater difficulty extracting a relational feature from the set of exemplars and using that as the basis for their discrimination or categorization of those exemplars.

The findings of this current research indicate that some children are especially drawn to absolute features of the exemplars and thereby fail to discriminate or categorize on the basis of the pitch direction relational feature that is present. Perhaps this abstract relational feature most easily emerges from a set of pitches as the pattern is continuously repeated. A synthesis of these findings implies that the perceptual priority of one type of stimulus feature over another is not a pervasive tendency for preschool children, but rather is dependent upon the task and the stimulus.

Another issue arises in the comparison of the literature on contour (multi-directional patterns) and the literature on direction (uni-directional patterns). The relational feature of uni-directional patterns may be more difficult to perceive than the relational feature of multi-directional contour patterns. The success that young children have with tasks involving contour (Morrongiello, et al. 1985; Pick, et al. 1988; Trehub, Morrongiello, & Thorpe, 1985) and the difficulty that so many have in tasks involving uni-directional patterns indicates that this is probable. Perhaps the complexity of the contour pattern makes the relational attribute more salient. Since the contour studies previously cited generally used patterns of five or six pitches with at least one change of direction, length of pattern and change of direction perhaps offer the perceiver more information about the relational feature that is present.

Gibson (1983) has suggested that the perception of a complex event may begin with the perception of shorter embedded events contained within the stimulus configuration. While uni-directional patterns are embedded events that occur within melodies, they cannot be assumed to be simpler events in terms of perceptual and cognitive processes. Available findings indicate that the concept of uni-directional pitch direction may be more difficult to acquire than the concept of multi-directional melodic contour, and that uni-directional patterns may in fact make the relational focus more difficult.

The categorization of melodic contour does not imply that the concept of pitch direction has been formed. Research is needed to explore the difference that seems to exist between the perception of the relational feature of contour and the relational feature of pitch direction. These apparent differences may just be artifacts of differing methodologies, but perhaps the differences reflect important aspects of perceptual and cognitive processing that need to be further understood.

From cognitive developmental research in the visual domain we know that young children are competent individuals who have a variety of cognitive skills at their disposal. However, in the aural-musical domain the evidence for such competence is not as readily available. The primary obstacle encountered in music development research has been the design of appropriate means of assessment to test the young child's musical understandings. Without objects to manipulate, or words with which to communicate, researchers have been limited in their choices of possible response modes and research designs. This study has shown that computer Touch Screen technology offers a valid means for non-verbal assessment of musical understandings. With the use of this new assessment procedure, some children as young as 3-1/2 can indicate that they discriminate and categorize pitch exemplars on the basis of pitch direction. However, this study has also shown that even with this non-verbal response mode, many young children are not performing these aural tasks.

These findings indicate that age and response methodology are not the only issues to be considered when musical cognitive development is investigated. The child's perceptual focus is also an important factor. The musical stimulus is complex. Assumptions must not be made that a feature of the stimulus that is most prominent to one perceiver will likewise be prominent to another. This especially needs to be kept in mind as adult, musically trained researchers prepare aural stimuli for young children. The feature that is salient to the trained ear may be ignored by the untrained listener. Without consideration of the perceptual tendencies of the young child, the interpretation of findings and the conclusions drawn from the research with young children may not accurately reflect their abilities.

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APPENDIX A

PARTICIPANT FORMS

LETTER TO PARENTS

UNIVERSITY OF WASHINGTON
Seattle, Washington 98195

January 7, 1988

Dear

I am writing to ask permission for your child,___________, to participate in a study I am conducting as part of my doctoral program in Systematic Musicology. I am interested in examining the preschool child's understanding of a basic music concept.

Sharon Bailey has given me permission to conduct this research during regular preschool sessions at the Woodinville Christian School. Further details of the study are included in the enclosed consent form. The study will occur during the months of January and February. If you have any questions, please feel free to call me at home. My phone number is 821-6875.

If you would like for your child to participate in the study, please return the enclosed information sheet and one copy of the consent form to your child's teacher or mail it to my home address.

A summary of the results will be available to you, if you are interested. Also, I will be glad to respond to questions you might have regarding the specific performance of your child.

Sincerely,

Deborah J. White

SCHOOL OF MUSIC
UNIVERSITY OF WASHINGTON
CONSENT FORM
THE DISCRIMINATION AND CATEGORIZATION OF PITCH DIRECTION BY THE YOUNG CHILD

Investigator:
Deborah J. White
Doctoral Candidate
Systematic Musicology
821-6875

Advisor:
James C. Carlsen
Chair
Systematic Musicology
543-7587

PURPOSE AND BENEFITS
This study is being conducted to determine if young children process music stimuli on the basis of pitch direction. This information is important to the development of a music curriculum for preschool children.

PROCEDURES
Each child will participate in group sessions with the preschool class as a whole. These group sessions are designed to familiarize the child with the investigator and the testing equipment. Each child will also participate in three individual 10-minute sessions playing a "game" with an Apple Computer. These individual sessions will be used to evaluate the child's understanding of the concept of pitch direction. All sessions will be conducted by the investigator.

RISKS, STRESS, OR DISCOMFORT
The sessions will be child-centered and activity-oriented so as to reduce any possible fatigue or discomfort.

OTHER INFORMATION. Identity of the children will remain confidential. The child is free to withdraw from the study at any time without penalty.

Signature of Investigator______________________ Date_______

Parent's Statement."The study described above has been explained to me, and I voluntarily consent to allow my child to participate in this research. I have had the opportunity to ask questions."

Name of Child_____________________________ Date_______

Signature of Parent/Legal Guardian_________________________

Copies to: Parent/Investigator's File

INFORMATION SHEET

1. Name of child ______________________________

2. Age of child ____________ Birthdate____/____/_____

3. Name of parent(s) or guardian ____________________

   Address ______________________________

   ____

4. To your knowledge, does your child have any

   hearing loss? ______________________________

5. Has your child received any musical training? _______

   If yes, please describe the type of training:

   ____

   ____

   ____

6. Would you like a summary of the results sent to you?

   ____

APPENDIX B

SCRIPT AND INSTRUCTIONS

Phase II - Training A: Visual Oddity Test

"We're going to play a game on my computer.

Look at the pictures. These two are the same;

this one is different; it doesn't belong.

Will you touch the one that doesn't belong?"

If correct, immediately reinforce with a positive comment such as "That's right! This one is different." and move quickly to the next trial.

If incorrect, press 'PRINT' button on the keypad to record the response.

"No, let's look again. This one is different.

Find the one that's different and touch it for me."

"Now let's do another one.

(Advance to next trial with keypad.)

See if you can find the one that's different."

Continue through all 12 trials providing positive or corrective feedback as necessary.

Phase III - Training B: Aural/Visual Stimuli Familiarization

"Today if you touch the shapes on the computer screen you will hear some music. (Touch one.)

Listen. Did you hear it? Now you touch one and see what happens."

Encourage each child to touch and listen.

<u>Phase IV</u> - <u>Discrimination Test</u>

Visual Oddity trial A on computer screen:

"Do you remember how we played this game? Two of these pictures are alike; one is different. Touch the one that's different."

Give appropriate feedback.

<u>Trial B</u> (an additional visual oddity trial)

"Which one is different?"

Advance to <u>trial C</u>.

"Do you remember what happens when you touch these shapes? They play music don't they? Well, today we're going to play the 'Touch the one that's different' game with the music. Listen."

The experimenter touches all three exemplars in 2 + 1 order. "Two of the shapes are playing the same music, but one is different. Did you hear it? These two are the same (re-listen), but this one is different (re-listen). This is the different one; it doesn't belong with the other two."

Advance to <u>trial D</u>.

"Now I want you to listen to these and see if you can hear that two are the same, but one doesn't belong. Listen to all three and then show me the one that's different."

This time allow the child to touch all three shapes.

Encourage re-listening if the child is hesitant about a response. "You can always listen again if you want to."

If the child wants to touch all three shapes in quick succession, guide the hand or point to each shape in turn to slow down the process.

The child needs to listen to the sound of one exemplar before touching the next one.

Allow the child to respond by touching the different one. Give appropriate feedback.

<u>Trial E</u> (an additional demonstration trial) will be used if the child needs further help in understanding the task.

Proceed with trials 1 - 12 giving appropriate feedback.

As mentioned earlier if the response is correct, immediately reinforce with a positive comment such as, "That's right!" and move quickly to the next trial.

If the response is incorrect, press the 'PRINT' button on the keypad to record the response and say, "No, let's listen again." Then touch the exemplars in 2 + 1 order. Point to the shapes as you say, "These two are the same, but this one is different. Now let's do another one. Listen for the one that is different."

To focus on the task of finding the different one, use phrases such as:

Show me the one that's different.

Can you find the different one?

Where is . . .

Find . . .

To keep attention focused as you proceed from trial to trial, use phrases such as these:

Let's try another one.

And how about these?

Listen to these.

Sprinkle in positive comments such as, "You're really listening well." "Good!" "That's fine." But don't saturate the situation or provide unearned praise.

Phase V - Categorization Test

"We're going to play another 'Touch the one that's different' game. Do you remember what to do?"

Trial A.

"Listen to these. Two of them will be doing something the same and one will be doing something different." Touch and listen to all three in 2 + 1 order. "I think these two are the same (re-listen to these) and this one is different (re-listen to it)."

"Now it's your turn. You listen to them and find the one that's different. Remember you can always listen again if you want to."

Follow the feedback guidelines already described and proceed with trials 1 - 12.

APPENDIX C

SUBJECT DATA SHEET

SUBJECT DATA SHEET

Subject # _____

Birthdate: ____________ Age Category 1 2 3 4

PHASE II - TRAINING A: VISUAL ODDITY TEST Score ______
(criterion 10 out of 12)

Observations:

PHASE III - TRAINING B: AURAL/VISUAL STIMULI FAMILIARIZATION

Observations:

PHASE IV - DISCRIMINATION TEST Score ______

Response Category 1 2 3 4

Observations:

PHASE V - CATEGORIZATION TEST Score ______

Observations:

VITA

NAME: Deborah Jeanne Kitts White

DATE OF BIRTH: January 29, 1950

PLACE OF BIRTH: Tazewell, Virginia

PARENTS: Howard S. and Mary F. Kitts

HUSBAND: Calvin Lee White

CHILD: Amy Leigh White

SECONDARY EDUCATION: Graham High School (1968)
Bluefield, Virginia

HIGHER EDUCATION: Bachelor of Arts (1979)
Northwest College
Kirkland, Washington

Master of Arts (1983)
Systematic Musicology
University of Washington
Seattle, Washington